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WADC TECHNICAL REPORT 58-476
VOLUME III

**THERMOPHYSICAL PROPERTIES
OF SOLID MATERIALS**

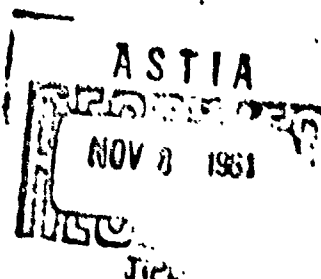
VOLUME III — CERAMICS

ALEXANDER GOLDSMITH
HARRY J. HIRSCHHORN
THOMAS E. WATERMAN

ARMOUR RESEARCH FOUNDATION

REVISED EDITION
NOVEMBER 1960

XEROX



WRIGHT AIR DEVELOPMENT DIVISION

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MATERIALS CENTRAL

CONTRACT No. AF 33(616)-5-112

PROJECT No. 7331

**WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO**

McGregor & Werner, Inc., Dayton, O.
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FOREWORD

This compilation of thermophysical property data was prepared by the Heat Transfer Section of the Fluid Dynamics and Systems Research Division of the Armour Research Foundation, Chicago, Illinois, under USAF Contract No. AF 33(616)-5212. This contract was initiated under Project No. 7381, "Thermophysical Data Consolidation", Task No. 73812, "Thermophysical Data for Solid Materials". The program was administered under the direction of Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Jules I. Wittsbert acting as project engineer.

These volumes cover work carried out from 1 July 1957 to 31 August 1960. The Materials Index, given in the forward portion of this volume, was arranged with the advice of W. H. Colner, S. W. Bradstreet and J. S. Griffith of the Ceramics Research Division.

The literature search was conducted by the staff of the Technical Information Research Section.

The study, evaluation, and compilation phases were carried out by the following personnel of the Heat and Mass Transfer Section: W. A. Gans, A. Goldsmith, J. I. Lang, H. J. Hirschhorn, and T. E. Waterman.

Computation, reading of published graphs, and plotting of data for this publication was done by D. Brast, G. Buzyna, M. Deahl, S. Chmel, A. Karazija, T. Schmugge, and a number of others.

The bulk of the typing of reproducible copy was done by Mrs. Mary A. Scroll.

The authors are particularly grateful to Mr. I. B. Fieldhouse, Supervisor of Heat and Mass Transfer, for his guidance and encouragement and to Mr. S. W. Bradstreet, Supervisor of Inorganic Technology for his aid in the area of Ceramics.

The entire effort at the Armour Research Foundation was directed by Alexander Goldsmith, project engineer.

ABSTRACT

Thermophysical property data, and their variation with temperature, are presented for a great number of solid materials, based on literature published during the period 1940-1957. Each reported value is shown and annotated, and recommended "most probable value" curves are given.

Materials covered include Elements, Alloys, Ceramics, Cermets, Intermetallics, Polymeric, and Composite Materials. Except for materials in the last two categories, only those melting above 1000°F are included.

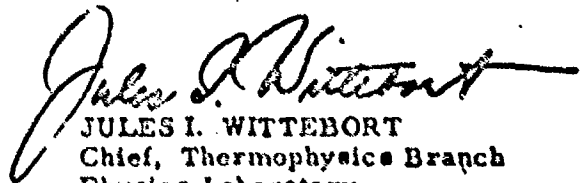
Properties covered include the following: Melting point, density, latent heats, specific heat, thermal conductivity, thermal diffusivity, emissivity, reflectivity, thermal expansion, vapor pressure, and electric resistivity.

Each of the four volumes is designed to be expansible, and it is expected that additional or revised data sheets for inclusion in these volumes will be forthcoming.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:


JULES I. WITTEBORT
Chief, Thermophysics Branch
Physics Laboratory
Materials Central

THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS

I. INTRODUCTION

At the initiative of the Materials Laboratory, Wright Air Development Center, and under its sponsorship, a program was undertaken to compile, evaluate, and consolidate all original test data on thermophysical properties of solid materials published during the period 1940-1957 inclusive. This publication contains the accumulated information and represents three years of effort. The data are presented in four volumes, divided as follows:

1. Elements
2. Alloys
3. Ceramics
4. Cermets, Intermetallics, Polymeric, and Composites

Each volume is designed to be expandable so that it will lend itself to the inclusion of new data as well as to the substitution of others. Additional data sheets for inclusion in these volumes will be published when available.

The collected data were obtained from a search of the following sources: (a) Chemical Abstracts, (b) Ceramic Abstracts, (c) Metallurgical Abstracts, (d) Nuclear Science Abstracts, and (e) Armed Services Technical Information Agency (ASTIA).

A detailed description of contents and of the method of presentation of data is given in the following several pages.

II. MATERIALS

Materials included in this survey are those which may find application in the design of aircraft, missiles, space vehicles, conventional or nuclear power plants, or allied equipment. Generally, only materials melting above 1000°F are included; exceptions are limited to the categories of plastics or composite materials. A listing of materials covered in the literature search is given in the Materials Index, which is described in Section IV-A below. This index also serves as a guide to the arrangement of data, and as a page numbering system. Due to the lack of published data, some of the materials listed in the index may not be represented by data sheets.

Manuscript released by authors 30 June 1960 for publication as a WADC Technical Report.

III. PROPERTIES

Physical properties included in this survey are the following:

<u>Property</u>	<u>Symbol</u>
1. Density	ρ
2. Melting Point	M. P.
3. Latent Heat of Fusion	Δh_f
4. Latent Heat of Vaporization	Δh_v
5. Latent Heat of Sublimation	Δh_s
6. Specific Heat (constant pressure)	c_p
7. Thermal Conductivity	k
8. Thermal Diffusivity	α
9. Emissivity, Reflectivity	ϵ, R
10. Linear Thermal Expansion	$\Delta L/L$
11. Vapor Pressure	p
12. Electric Resistivity	r

The first five properties in the above list are given as single point values, in individual tables grouped on a single sheet. The others are presented graphically as functions of temperature. All data on linear thermal expansion have been reduced to a datum of 20°C; i.e. $\Delta L/L = 0$ at 528°R (293°K).

IV. CONTENTS

Each of the four volumes of data consists of four sections arranged in the following order:

1. Introductory remarks and explanatory text
2. Materials Index
3. Tables of Conversion Factors
4. Body of Data

The fifth volume, or Appendix, consists of the following sections:

1. Introductory remarks and explanatory text
2. Materials Index
3. List of References
4. Author Index (alphabetic)

A. Materials Index

The Materials Index, located in the front portion of each volume following these introductory pages, gives the order in which the body of data is arranged. It is based, with few exceptions, on the chemical composition of materials, and is arranged in outline fashion. It can have four orders of subdivision designated by Roman numerals, capital letters, common numerals and lower case letters such as:

L A. 1. a.

Each category, even in the lowest order, represents a family of materials, rather than a specific one, so that the number of individual materials that can be accommodated is virtually unlimited. The index lends itself to future expansion.

B. Body of Data

The body of data is arranged by materials in the order of the Materials Index. Properties for a given small family of materials are given in the order listed in Section III above. Each plotted point or numerical value in the body of data is identified as to source by reference to the List of References.

C. List of References

The List of References gives complete bibliographic notations for all the references from which usable data have been extracted. These are arranged chronologically by year of publication, and in an arbitrary sequence within any given year.

D. Author Index

The Author Index is arranged in alphabetic order by author's surname. Coauthors are also included. Each entry is cross-referred to the List of References where a complete bibliographic notation is given.

V. METHOD OF PRESENTATION OF DATA

A. Format

A "unit" of information in this volume consists of a single sheet having a graph on one face and reference information on the back. The first five properties listed in Section III above are referred to as "point values" and are grouped together as a "unit" on a single sheet in the same manner as a graph.

B. Pagination

Each volume is designed to be expandable, and therefore is not compatible with conventional page numbering. The system adopted is as follows:

The body of data is arranged by materials in accordance with the Materials Index which is located in the forward portion of each volume. Furthermore, for a given small family of materials, data for the several properties are arranged in accordance with the listing given in Section III above. The Materials Index designation is given in the lower right corner of each graph or data sheet in lieu of a page number. This identification is not unique since several materials of the same family carry the same designation, but it guides the reader to the approximate location of the desired information.

Materials that do not fit into any subgroup presently listed in the Materials Index are designated by the next higher order grouping.

Example: Nickel-Silicon alloys are not specifically identified as a family grouping in the Materials Index. These therefore, are designated by the next higher order of subdivision, namely, Nickel-Base Alloys, category IV-A in the index.

Data for such materials are located at the end of the group; that is, after those materials which do fit into a currently identified subgroup. Within this framework, where necessary, data sheets are further arranged in alphabetic order by the major alloying element. It is expected that after the initial familiarization with this arrangement, the user will be able to locate the desired information (or convince himself of its absence) with a minimum of page-by-page searching.

A unique identification of each sheet is provided by the number in the lower left corner of the sheet. The initial two digits of this number give the year when the sheet was prepared; the latter digits are merely a numerical sequence for identification purposes only and serve no other purpose.

C. Graph Sheets

Data extracted from various references on the same subject (material and property) are identified on each graph by means of distinctive plotting symbols. These symbols indicate the data of a given investigator, but do not necessarily imply actual test points. In numerous instances in the literature an author presents only smoothed data, either graphically or in tabular form, and it is frequently impossible to distinguish these from actual test values.

In presenting data on thermal expansion, an investigator sometimes gives only a coefficient of expansion for a considerable temperature range. In such instances it is assumed that a linear relationship is implied, and in plotting such data the straight line may be indicated by more than the two end-points in order that the given investigator's data not be obscured by those of others.

With regard to specific heat, some investigators present only total heat content of the material above a given datum, and make no attempt to reduce such data to specific heat. In such instances the investigator's enthalpy data were fitted with a quadratic equation of the form $\Delta H = A + BT + CT^2$ using a least-mean-square procedure to determine the coefficients. This equation was then differentiated with respect to temperature to obtain a linear variation of specific heat with temperature. Instances where this was done are so indicated.

Curves drawn through the plotted points are deemed "most probable value" curves based on the data presented. As additional information from other investigators is added in the future, it may be necessary to modify these curves.

D. Point Values

The first five properties listed in Section III above are considered point functions (at standard temperature and pressure unless indicated otherwise) and are grouped in individual tables, by property, on a single sheet. Data extracted from various references are identified by distinctive plotting symbols in the same manner as points on a graph. "Most probable values", usually based only on the data presented, are given at the top of the page. In some instances where data were not available from the current survey, density and melting point information was taken from secondary (nonoriginal) sources. These appear only at the top of the sheet and are identified as to source. Melting points of binary alloys, representing the solidus line on a phase diagram, have generally not been included. Many of these are given by Hansen and Anderko in "Constitution of Binary Alloys" (Ref. 58-11).

E. Reference Information

1. Symbol

The plotting symbols are identical with, and correspond to those used on the face of a given graph or data sheet.

2. Investigator

The investigator, or author, of each reference is identified by name. Coauthors are included.

3. Reference

References are identified by hyphenated numbers such as 00-00, which serve to locate the bibliographic entry for the given source in the List of References in the Appendix. The initial two digits indicate the year of publication. The remaining number locates the specific reference within the given year.

Example: Ref. 54-7 is found in the List of References under the year 1954; the seventh entry of that year. It is an article by R. W. Powell entitled "The Thermal Conductivity of Beryllia".

References which are not dated are identified with the letters ND in place of the year of publication, such as ND-00. Undated references are listed at the end of the List of References.

4. Range

The column marked "Range, *R" indicates the temperature range covered by the data in the given reference.

5. Material Composition

This column contains any pertinent information given in a reference that serves to describe the material investigated. Primarily this consists of the chemical composition of the material, its purity, density, and common trade name when given. Where a material was identified by trade name only, the nominal composition was added.

6. Test Method

A general indication of the test method used by the investigator is given in this column. While test methods for a given property can be reasonably grouped into several broad categories, each investigator makes his own modifications and alterations which do not lend themselves to brief description.

7. Remarks

Pertinent remarks concerning the given data are included in this column. Such remarks may describe a prior treatment of the material, the environment during the test, the author's estimate of accuracy, or similar information.

MATERIALS INDEX

MAJOR HEADINGS

- I. ELEMENTS (Melting temperature above 1000°F)
- II. IRON BASE ALLOYS
- III. COPPER BASE ALLOYS
- IV. NICKEL BASE, COBALT BASE, AND REFRACTORY METAL
BASE ALLOYS
- V. LIGHT METAL ALLOYS (Including Ti Alloys)
- VI. OTHER METAL ALLOYS (Melting temperature above 1000° F)
- VII. CERAMICS (Including Glasses)
- VIII. CERMETS
- IX. INTERMETALLICS
- X. POLYMERIC MATERIALS (Including Plastics)
- XI. COMPOSITE MATERIALS

MATERIALS INDEX

I.

ELEMENTS (Melting temperature above 1000° F)

	<u>Element</u>	<u>Symbol</u>
I - A - 1	Actinium	Ac
I - A - 2	Aluminum	Al
I - A - 3	Americium	Am
I - A - 4	Antimony	Sb
I - A - 5	Arsenic	As
I - A - 6	Astatine	At
I - B - 1	Barium	Ba
I - B - 2	Berkelium	Bk
I - B - 3	Beryllium	Be
I - B - 4	Boron	B
I - C - 1	Calcium	Ca
I - C - 2	Californium	Cf
I - C - 3	Carbon	C
	a. Extruded Acheson graphite, multicrystalline	
	b. Extruded Acheson amorphous carbon	
	c. Extruded Acheson graphite, impregnated	
	d. Molded Acheson graphite, multicrystalline	
	e. Molded Acheson amorphous carbon	
	f. Molded Acheson graphite, impregnated	
	g. Lampblack - base carbon or graphite	
	h. Pyrolytic graphite	
	j. Natural graphite-base graphite	
	k. Natural graphite-base carbon	
	m. Diamond	
	n. Single crystal graphite	
	p. Lampblacks	
I - C - 4	Cerium	Ce
I - C - 5	Chromium	Cr
I - C - 6	Cobalt	Co
I - C - 7	Copper	Cu
I - C - 8	Curium	Cm
I - D - 1	Dysprosium	Dy
I - E - 1	Einsteinium	E
I - E - 2	Erbium	Er
I - E - 3	Europium	Eu
I - F - 1	Fermium	Fm
I - F - 2	Francium	Fr

I.

ELEMENTS (Continued)

	<u>Element</u>	<u>Symbol</u>
I - G - 1	Gadolinium	Gd
I - G - 2	Germanium	Ge
I - G - 3	Gold	Au
I - H - 1	Hafnium	Hf
I - H - 2	Holmium	Ho
I - J - 1	Iridium	Ir
I - J - 2	Iron	Fe
I - L - 1	Lanthanum	La
I - L - 2	Lutetium	Lu
I - M - 1	Magnesium	Mg
I - M - 2	Manganese	Mn
I - M - 3	Mendelevium	Mv
I - M - 4	Molybdenum	Mo
I - N - 1	Neodymium	Nd
I - N - 2	Neptunium	Np
I - N - 3	Nickel	Ni
I - N - 4	Niobium (Columbium)	Nb
I - N - 5	Nobelium	No
I - O - 1	Osmium	Os
I - P - 1	Palladium	Pd
I - P - 2	Platinum	Pt
I - P - 3	Plutonium	Pu
I - P - 4	Polonium	Po
I - P - 5	Praseodymium	Pr
I - P - 6	Promethium	Pm
I - P - 7	Protactinium	Pa
I - R - 1	Radium	Ra
I - R - 2	Rhenium	Re
I - R - 3	Rhodium	Rh
I - R - 4	Ruthenium	Ru
I - S - 1	Samarium	Sm
I - S - 2	Scandium	Sc
I - S - 3	Silicon	Si
I - S - 4	Silver	Ag
I - S - 5	Strontium	Sr

I.

ELEMENTS (Continued)

	<u>Element</u>	<u>Symbol</u>
I - T - 1	Tantalum	Ta
I - T - 2	Technetium	Tc
I - T - 3	Terbium	Tb
I - T - 4	Thorium	Th
I - T - 5	Thulium	Tm
I - T - 6	Titanium	Ti
I - T - 7	Tungsten	W
I - U - 1	Uranium	U
I - V - 1	Vanadium	V
I - Y - 1	Ytterbium	Yb
I - Y - 2	Yttrium	Y
I - Z - 1	Zirconium	Zr

II.

IRON BASE ALLOYS

(Iron greatest weight fraction with one or more other elements.)

A. Plain Carbon Steels (Mn < 2.5%; Si < 0.36%; P, S < 0.051%, each)

1. $0.02 < C \leq 0.20\%$
2. $0.20 < C \leq 0.40\%$
3. $0.40 < C \leq 0.60\%$
4. $0.60 < C \leq 0.80\%$
5. $0.80 < C \leq 1.00\%$
6. $1.00 < C \leq 1.20\%$
7. $1.20 < C \leq 1.50\%$
8. $1.50 < C \leq 2.00\%$

B. Cast Irons

1. Gray, unalloyed and low alloy (Less than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
2. Gray, alloyed (More than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
3. White, unalloyed and low alloy (Less than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
4. White, alloyed (More than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
5. Malleable, Ferritic
6. Malleable, Pearlitic
7. Nodular, Ferritic
8. Nodular, Pearlitic

II.

IRON-BASE ALLOYS (Continued)

C. Low Alloy Steels (Less than 10% of any single alloying element, exclusive of C; Mn < 2.5%; Si < 0.36%; P, S < 0.051% each. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements; $X = X_1 + X_2 + \dots$)

1. Fe + Ni
2. Fe + Ni + Cr + X
3. Fe + Ni + Mo + X
4. Fe + Ni + X ($X_1 \neq \text{Mo, Cr}$)
5. Fe + Mo + X
6. Fe + Cr + X ($X_1 \neq \text{Mo}$)
7. Fe + Cr + Mo + X
8. Fe + W + X
9. Fe + Si + X

D. High Alloy Steels (More than 10% of any single alloying element exclusive of C; Mn < 2.5%; Si < 1.00%; P, S < 0.051% each. Alloying elements listed in decreasing order of their weight fraction. X may be none, one, or more elements; $X = X_1 + X_2 + \dots$)

1. Fe + Cr
2. Fe + Cr + Ni
3. Fe + Cr + Ni + X ($X_1 \neq 0$)
 - a. Fe + Cr + Ni + Co + X
4. Fe + Cr + X ($X_1 \neq 0, \text{Ni}$)
5. Fe + Ni
6. Fe + Ni + X ($X_1 \neq 0$)
 - a. Fe + Ni + Cr + X
7. Fe + Al + X
8. Fe + W + X
9. Fe + Mn + X

III. COPPER-BASE ALLOYS

(Copper greatest weight fraction with one or more other elements.
Alloying elements listed in decreasing order of their weight fractions.
X may be none, one, or more elements.)

A. Copper + Zinc + X

1. Cu + Zn + Pb + X
2. Cu + Zn + Sn + X
3. Cu + Zn

B. Copper + Tin + X

1. Cu + Sn + Pb + X
2. Cu + Sn + Zn + X
3. Cu + Sn

C. Copper + Lead + X

D. Copper + Nickel + X

E. Copper + Aluminum + X

F. Copper + Silicon + X

G. Copper + Beryllium + X

H. Copper + Manganese + X

J. Copper + Tellurium + X

K. Copper + Chromium + X

L. Copper + Zirconium + X

IV. NICKEL-BASE, COBALT-BASE, AND REFRACTORY METAL-BASE ALLOYS

(Major element greatest weight fraction with one or more other elements.
Alloying elements listed in decreasing order of their weight fractions.
X may be none, one, or more elements.)

A. Nickel-Base Alloys

1. Ni + Cu + X
2. Ni + Mo + X
3. Ni + Co + X
 - a. Ni + Co + Cr + X
4. Ni + Fe + X
 - a. Ni + Fe + Cr + X
5. Ni + Cr + X
 - a. Ni + Cr + Fe + X
6. Ni + Mn + X

B. Cobalt-Base Alloys

1. Co + Cr + X
2. Co + Ni + X
3. Co + Fe + X
4. Co + Pd + X

C. Tungsten-Base Alloys

D. Molybdenum-Base Alloys

E. Niobium-Base Alloys

F. Chromium-Base Alloys

1. Cr + Ni + X
2. Cr + Mo + X

G. Vanadium-Base Alloys

H. Tantalum-Base Alloys

J. Zirconium-Base Alloys

1. Zr + Sn + X
2. Zr + Nb + X
3. Zr + U + X

K. Hafnium-Base Alloys

L. Thorium-Base Alloys

V. LIGHT METAL ALLOYS (Including Ti Alloys)

(Major element greatest weight fraction with one or more other elements. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements; $X = X_1 + X_2 + \dots$)

A. Aluminum-Base Alloys

1. Al + Cu + X
2. Al + Si + X
 - a. Al + Si + Cu + X
 - b. Al + Si + Mg + X
3. Al + Mg + X
4. Al + Zn + X
5. Al + Mn + X
6. Al + Ag + X

B. Magnesium-Base Alloys

1. Mg + Al + Zn + X
2. Mg + Al + X ($X_1 \neq \text{Zn}$)
3. Mg + Rare Earth + X
4. Mg + Th + X
5. Mg + Li + X
6. Mg + Zn + X

C. Titanium-Base Alloys

1. Ti + Al + X
2. Ti + Mn + X
3. Ti + Mo + X
4. Ti + V + X
5. Ti + Cr + X
6. Ti + Fe + X ($X_1 \neq \text{Cr}$)
7. Ti + Fe + Cr + X
8. Ti + O + X

D. Beryllium-Base Alloys

VI. OTHER METAL ALLOYS, melting temperature above 1000°F

(Major element greatest weight fraction with one or more other elements.
Alloying elements listed in decreasing order of their weight fractions.
X may be none, one, or more elements.)

A. Gold-Base Alloys

1. Au + Cd + X
2. Au + Co + X
3. Au + Pd + X
4. Au + Ni + X
5. Au + Mn + X

B. Silver-Base Alloys

1. Ag + Al + X
2. Ag + Cd + X
3. Ag + Cu + X
4. Ag + Pd + X

C. Platinum-Base Alloys

D. Palladium-Base Alloys

1. Pd + Au + X
2. Pd + Co + X
3. Pd + Cu + X

E. Manganese-Base Alloys

1. Mn + Cu + X
2. Mn + Ni + X

F. Uranium-Base Alloys

1. U + Cr + X
2. U + Mo + X
3. U + Zr + X

G. Silicon-Base Alloys

1. Si + Fe + X

VII. CERAMICS

- A. Oxide Ceramics (Nominal oxide; or nominal oxide greatest weight fraction with one or more other oxides. X may be none, one, or more oxides. Also see VII-B and VII-E.)
1. Aluminum Oxide + X
 - a. Aluminum oxide (alumina, corundum, sapphire)
 - b. Aluminum oxide + Chromium oxide + X
 2. Beryllium Oxide + X
 - a. Beryllium oxide (beryllia, bromellite)
 3. Calcium Oxide + X
 - a. Calcium oxide (calcia, lime)
 4. Rare Earth Oxides (Atomic Numbers 57-71 in Alphabetic Order)
 - a. Cerium oxide + X (ceria)
 - b. Dysprosium oxide + X (dysprosia)
 - c. Erbium oxide + X (erbia)
 - d. Europium oxide + X (europia)
 - e. Gadolinium oxide + X (gadolinia)
 - f. Holmium oxide + X
 - g. Lanthanum oxide + X (lanthana)
 - h. Lutetium oxide + X
 - j. Neodymium oxide + X (neodymia)
 - k. Praseodymium oxide + X (praseodymia)
 - m. Promethium oxide + X
 - n. Samarium oxide + X (samarita)
 - p. Terbium oxide + X (terbia)
 - q. Thulium oxide + X (thulia)
 - r. Ytterbium oxide + X (ytterbia)
 5. Magnesium Oxide + X
 - a. Magnesium oxide (magnesia, periclase)
 6. Silicon Oxide + X (silica, cristobalite, quartz; see also VII-C-6)
 7. Thorium Oxide + X (thoria, thorizite)
 8. Titanium Oxide + X (anatase, brookite, rutile)
 9. Hafnium Oxide + X; Zirconium Oxide + X
 - a. Hafnium oxide (hafnia)
 - b. Zirconium oxide (zirconia)

VII. CERAMICS (Continued)

A. Oxide Ceramics (Continued)

10. Uranium Oxide + X
11. Plutonium Oxide + X
- 12.
13. Other Oxide Ceramics, in Alphabetic Order: A-I
14. Other Oxide Ceramics, in Alphabetic Order : J-R
15. Other Oxide Ceramics, in Alphabetic Order: S-Z

B. Mineral Ceramics (Also see VII-A and VII-E)

1. Aluminosilicates, non-hydrous (mullite, kyanite, sillimanite)
2. Silicates of Ba, Be, Ca, Fe, Mg, Mn, Ni, Sr, and Zn in order listed.
3. Alkali and alkaline-earth aluminosilicates (feldspars)
 - a. Barium-modified feldspar
 - b. Beryllium-modified feldspar (beryl)
 - c. Calcium-modified feldspar
 - d. Cesium-modified feldspar
 - e. Lithium-modified feldspar
 - Magnesium aluminosilicate, see VII-E-3
 - f. Potassium feldspar
 - g. Rubidium feldspar
 - h. Sodium feldspar
 - j. Strontium-modified feldspar
4. Hafnium silicate; Zirconium silicate
 - a. Hafnium silicate (hafnon)
 - b. Zirconium silicate (zircon)
5. Borates (borax, colemanite); Phosphates

VII. CERAMICS (Continued)

B. Mineral Ceramics (Continued)

6. Hafnates; Niobates; Titanates; Zirconates

- a. Hafnates
- b. Niobates
- c. Zirconates
- d. Aluminum titanate
- e. Barium titanate
- f. Calcium titanate
- g. Iron titanate
- h. Lithium titanate
- j. Magnesium titanate
- k. Strontium titanate
- m. Zinc titanate
- n. Zirconium titanate

7. Aluminates

- a. Magnesium aluminate (spinel)
- b. Barium aluminate
- c. Beryllium aluminate
- d. Calcium aluminate
- e. Cesium aluminate
- f. Lithium aluminate
- g. Potassium aluminate
- h. Rubidium aluminate
- j. Sodium aluminate
- k. Strontium aluminate
- m. Zinc aluminate

8. Ferrites

- a. Magnesium ferrite
- b. Barium ferrite
- c. Beryllium ferrite
- d. Calcium ferrite
- e. Cesium ferrite
- f. Lithium ferrite
- g. Potassium ferrite
- h. Rubidium ferrite
- j. Sodium ferrite
- k. Strontium ferrite
- m. Cobalt ferrite
- n. Nickel ferrite
- p. Zinc ferrite

9. Micac (Illites)

10. Asbestos minerals

VII. CERAMICS (Continued)

C. Vitreous Structures

1. Silic glasses
 - a. Lithium silicate glass
 - b. Sodium silicate glass
 - c. Potassium silicate glass
 - d. Rubidium silicate glass
 - e. Cesium silicate glass
 - f. Beryllium silicate glass
 - g. Magnesium silicate glass
 - h. Calcium silicate glass
 - j. Strontium silicate glass
 - k. Barium silicate glass
 - m. Lead silicate glass
2. Borate glasses
3. Phosphate glasses
4. Arsenic oxide glasses
5. Borosilicate glasses (pyrex)
6. Silica glasses (fused quartz)

D. Covalent Ceramic Structures (Also see Section IX)

1. Silicon carbide + X
 - a. Silicon carbide
 - b. Silicon carbide + Boron carbide + X
2. Boron carbides
3. Alkali and alkaline earth carbides
 - a. Beryllium carbide
4. Boron nitrides
5. Halides and oxyhalides
 - a. Fluorides
6. Sulfides; Selenides

VII. CERAMICS (Continued)

E. Vitreous Bonded Crystalline Ceramics (conventional ceramics; also see VII-A and VII-B)

1. Alkaline earth silicate glass bond
2. Alkali silicate glass bond
3. Magnesium aluminosilicate glass bond (cordierite, steatite talc body)
 - a. Lithium modified
 - b. Sodium modified
 - c. Potassium modified
 - d. Rubidium modified
 - e. Cesium modified
 - f. Beryllium modified
 - g. Calcium modified
 - h. Strontium modified
 - j. Barium modified
 - k. Lead modified
4. Calcium aluminosilicate glass bond (porcelain)
5. Other alkaline earth aluminosilicates glass bond
6. Alkali aluminosilicate glass bond
7. Borosilicate glass bond
8. Phosphate glass bond
9. Alumina firebrick
10. Basic brick
11. Silica brick

F. Inorganic Cements and Adhesives

VIII. CERMETS

(Nominal refractory phase is that which is greatest weight fraction of total refractory phase.)

A. Cermets Containing Carbides as Major Refractory Phase

1. Tungsten carbide as major refractory phase
2. Titanium carbide as major refractory phase
3. Chromium carbide as major refractory phase
4. Hafnium carbide or Zirconium carbide as major refractory phase
5. Silicon carbide as major refractory phase

B. Cermets Containing Oxides or Suboxides as Major Refractory Phase

1. Aluminum oxide as major refractory phase
2. Magnesium oxide as major refractory phase
3. Uranium oxide as major refractory phase
4. Thorium oxide as major refractory phase
5. Beryllium oxide as major refractory phase

C. Cermets Containing Borides as Major Refractory Phase

1. Zirconium boride as major refractory phase

D. Cermets Containing Silicides as Major Refractory Phase

E. Cermets Containing Nitrides as Major Refractory Phase

F. Cermets Containing Hydrides as Major Refractory Phase

IX. INTERMETALLICS

(Nominal intermetallic, or nominal intermetallic greatest weight fraction with one or more other intermetallics. Also see section VII - D and respective alloy system.)

A. Carbide Systems

1. Tungsten carbide
2. Titanium carbide
3. Chromium carbide
4. Hafnium carbide; Zirconium carbide
5. Tantalum carbide
6. Molybdenum carbide
7. Uranium carbide

B. Silicide Systems

1. Molybdenum silicide
2. Uranium silicide

C. Boride Systems

1. Magnesium boride
2. Titanium boride
3. Zirconium boride

D. Nitride Systems

1. Titanium nitride
2. Uranium nitride
3. Zirconium nitride

E. Hydride Systems

1. Lithium hydride
2. Zirconium hydride

F. Antimonide, Arsenide, Phosphide, Telluride Systems

1. Antimonides
2. Tellurides

IX. INTERMETALLICS (Continued)

G. Intermetallics Involving a Light Metal (Al, Be, Mg, Ti)

1. Aluminides
2. Beryllides
3. Magnesium intermetallics
4. Titanium intermetallics

H. Intermetallics Involving a Rare Earth

J. Intermetallics Involving a Refractory Metal

1. Chromium intermetallics
2. Cobalt intermetallics
3. Hafnium intermetallics
4. Molybdenum intermetallics
5. Nickel intermetallics
6. Niobium intermetallics
7. Tantalum intermetallics
8. Thorium intermetallics
9. Tungsten intermetallics
10. Vanadium intermetallics
11. Zirconium intermetallics

For intermetallics not listed above, see respective alloy system.

X. POLYMERIC MATERIALS (Including plastics and filled plastics)

A. Polyesters

1. Cellulose acetate
2. Cellulose propionate
3. Cellulose acetate butyrate
4. Cellulose nitrate
5. Ethyl cellulose
6. Polyvinyl acetals
7. Polyvinyl acetate
8. Copolyvinyl chloride-acetate
9. Isocyanates
10. Polyurethanes
11. Unsaturated polyesters

B. TAC Polyesters (tri-allyl cyanurate)

C. Phenolics

1. Phenol formaldehyde
2. Furfural formaldehyde
3. Urea formaldehyde

D. Epoxides

E. Melamines

F. Acrylics

G. Polyethylene and halogenated polyethylenes

H. Polyamide (nylon)

J. Natural and Synthetic Rubber

XI. COMPOSITE MATERIALS

(The word "ceramic", as used below, includes any material which is inorganic and nonmetallic. Semiorganic materials, such as silicones, are included in the term "organic".)

- A. Composite Organic Materials; Sandwich Structures. (Any layer may be pure, filled, or reinforced.)
 - 1. Plastic skin, plastic foam core
 - 2. Plastic skin, plastic honeycomb core
 - 3. Solid plastic layers
- B. Composite Metallic Materials
 - 1. Metal skin, metal honeycomb core
 - 2. Unbonded metal layers
 - 3. Fusion bonded metal layers
 - 4. Mechanically bonded metal layers
 - 5. Clad metals
 - 6. Plated metals
- C. Composite Ceramic Materials
- D. Composite Organic - Metallic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)
 - 1. Plastic skin, metal honeycomb core
 - 2. Metal skin, plastic honeycomb core
 - 3. Metal skin, plastic foam core
 - 4. Adhesive bonded metal layers
- E. Composite Metallic - Ceramic Materials
- F. Composite Organic - Ceramic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)
- G. Composite Organic - Metallic - Ceramic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)

XI. COMPOSITE MATERIALS (Continued)

H. Reinforced Organic Materials

1. Reinforced teflon
2. Reinforced melamine formaldehyde
3. Reinforced phenolics
4. Reinforced diallyl phthalate
5. Reinforced polyesters and TAC polyesters
6. Reinforced silicones
7. Reinforced epoxides

J. Reinforced Ceramic Materials

CONVERSION FACTORS FOR DENSITY

1 g/cm ³ = 1	g/cm ³	g/in ³	kg/m ³	kg/ft ³	lb/in ³	lb/ft ³
1 g/in ³ = 0.0610234	1	16.38716	10 ³	28.3170	0.0361275	62.4283
1 kg/m ³ = 10 ⁻³	10 ⁻³	0.01638716	1	0.0283170	3.61275 x 10 ⁻⁵	0.0624283
1 kg/ft ³ = 0.0351446	0.0351446	0.578704	35.31446	1	1.275824 x 10 ⁻³	2.20462
1 lb/in ³ = 27.6797	27.6797	453.592	27679.7	783.808	1	1728
1 lb/ft ³ = 0.01601837	0.01601837	0.262496	16.01837	453.592	5.78704 x 10 ⁻⁴	1

These tables are based on conversion factors given in "Tables of Thermal Properties of Gases", National Bureau of Standards Circular 564, November 1, 1955.

CONVERSION FACTORS FOR SPECIFIC HEAT

	cal/g °K	$\frac{\text{joules}}{\text{g} \cdot \text{K}}$	$\frac{\text{watt sec}}{\text{g} \cdot \text{K}}$	Btu/lb °R
1 cal/g °K =	1	4.184	4.184	0.999346
1 $\frac{\text{joules}}{\text{g} \cdot \text{K}}$ =	0.239006	1	1	0.238849
1 $\frac{\text{watt sec}}{\text{g} \cdot \text{K}}$ =	0.239006	1	1	0.238849
1 Btu/lb °R =	1.000654	4.18674	4.18674	1

CONVERSION FACTORS FOR LATENT HEAT

	cal/g	joules/g	$\frac{\text{watt sec}}{\text{g}}$	Btu/lb
1 cal/g =	1	4.184	4.184	1.798823
1 joules/g =	0.239006	1	1	0.429929
1 $\frac{\text{watt sec}}{\text{g}}$ =	0.239006	1	1	0.429929
1 Btu/lb =	0.555919	2.32597	2.32597	1

CONVERSION FACTORS FOR THERMAL CONDUCTIVITY

$1 \frac{\text{Watt}}{\text{cm}^2 \cdot ^\circ\text{K}}$	$\frac{\text{Watts}}{\text{cm}^2 \cdot ^\circ\text{K}}$	$\frac{\text{Watts}}{\text{in}^2 \cdot ^\circ\text{R}}$	$\frac{\text{cal}}{\text{sec cm}^2 \cdot ^\circ\text{K}}$	$\frac{\text{Btu in}}{\text{hr ft}^2 \cdot ^\circ\text{R}}$	$\frac{\text{Btu}}{\text{hr ft}^2 \cdot ^\circ\text{R}}$	$\frac{\text{Btu}}{\text{sec in}^2 \cdot ^\circ\text{R}}$	$\frac{\text{Btu}}{\text{hr in}^2 \cdot ^\circ\text{R}}$	$\frac{\text{k cal}}{\text{hr m}^2 \cdot ^\circ\text{K}}$
$1 \frac{\text{Watt}}{\text{cm}^2 \cdot ^\circ\text{K}} =$	1	1.4111	0.2390	693.4	57.78	1.337×10^{-3}	4.81499	86.04
$1 \frac{\text{Watt}}{\text{in}^2 \cdot ^\circ\text{R}} =$	0.7087	1	0.16937	491.4	40.946	9.478×10^{-4}	3.412	60.97
$1 \frac{\text{cal}}{\text{sec cm}^2 \cdot ^\circ\text{K}} =$	4.184	5.904	1	2901	241.8	5.596	20.15	360
$1 \frac{\text{Btu in}}{\text{hr ft}^2 \cdot ^\circ\text{R}} =$	1.4423×10^{-3}	2.035×10^{-3}	3.447×10^{-4}	1	0.08333	1.9290×10^{-6}	6.944×10^{-3}	0.12409
$1 \frac{\text{Btu}}{\text{hr ft}^2 \cdot ^\circ\text{R}} =$	0.01731	0.02442	4.136×10^{-3}	12	1	2.3148×10^{-5}	0.08333	1.4891
$1 \frac{\text{Btu}}{\text{sec in}^2 \cdot ^\circ\text{R}} =$	747.7	1.0550	178.70	518,400	43,200	1	3600	6.433×10^4
$1 \frac{\text{Btu}}{\text{hr in}^2 \cdot ^\circ\text{R}} =$	0.2077	0.2931	0.04964	144	12	2.778×10^{-4}	1	17.87
$1 \frac{\text{k cal}}{\text{hr m}^2 \cdot ^\circ\text{K}} =$	0.011622	0.016400	2.778×10^{-3}	8.058	0.6715	1.55447×10^{-5}	0.05596	1

CONVERSION FACTORS FOR DIFFUSIVITY

	ft^2/hr	ft^2/sec	in^2/sec	cm^2/hr	cm^2/sec
$1 \text{ ft}^2/\text{hr} =$	1	2.778×10^{-4}	0.04	929.0	0.2581
$1 \text{ ft}^2/\text{sec} =$	3600	1	144	3.3445×10^6	929.0
$1 \text{ in}^2/\text{sec} =$	25	6.944×10^{-3}	1	2.323×10^4	6.452
$1 \text{ cm}^2/\text{hr} =$	1.0764×10^{-3}	2.990×10^{-7}	4.306×10^{-5}	1	2.778×10^{-4}
$1 \text{ cm}^2/\text{sec} =$	3.875	1.0764×10^{-3}	0.15500	3600	1

CONVERSION FACTORS FOR VAPOR PRESSURE

	dyne/cm ²	standard atmosphere	kg/cm ²	mm Hg	in Hg	lb/in ²	lb/ft ²
1 dyne/cm ² =	1	9.869×10^{-7}	1.0197×10^{-6}	7.501×10^{-4}	2.953×10^{-5}	1.4504×10^{-5}	2.089×10^{-3}
1 standard atmosphere =	1.0133×10^6	1	1.0332	760	29.92	14.696	2116
1 kg/cm ² =	9.807×10^5	0.9678	1	735.6	28.96	14.223	2048
1 mm Hg =	1333.2	1.3158×10^{-3}	1.3595×10^{-3}	1	0.03937	0.019337	2.7145
1 in Hg =	3.386×10^4	0.03342	0.03453	25.40	1	0.4912	70.71
1 lb/in ² =	6.8947×10^4	0.068046	0.07031	51.71	2.036	1	144
1 lb/ft ² =	478.8	4.725×10^{-4}	4.882×10^{-4}	0.3591	0.014139	6.944×10^{-3}	1

PROPERTIES OF ALUMINUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	250 lb _m /ft ³ *	4.0 g/cm ³ *
Melting Point.	4160 °R	2310 °K
Heat of Fusion		
Heat of Vaporisation. . .		
Heat of Sublimation . . .	8052 ₅₃₇ °R Btu/lb _m	4473 ₂₉₈ °K cal/g

* Value for α-phase; for γ-phase, see Reported Values below

REPORTED VALUES

Density:	lb _m /ft ³	g/cm ³	Material
○	250	4.0	α phase
○	212	3.4	γ phase
○	222.18 ± 0.06	3.559 ± 0.001	sinter
○	248.65 ± 0.06	3.983 ± 0.001	sapphire

Melting Point:	°R	°K
Δ	4155 ± 18	2308 ± 10
○	4085 ± 2	2267 ± 1
▽	4092 ± 18	2273 ± 10
○	4100 ± 10	2278
○	4182	2323
Δ	4167 ± 13	2315 ± 7
△	4153 ± 29	2307 ± 16

Heat of Fusion:	Btu/lb _m	cal/g
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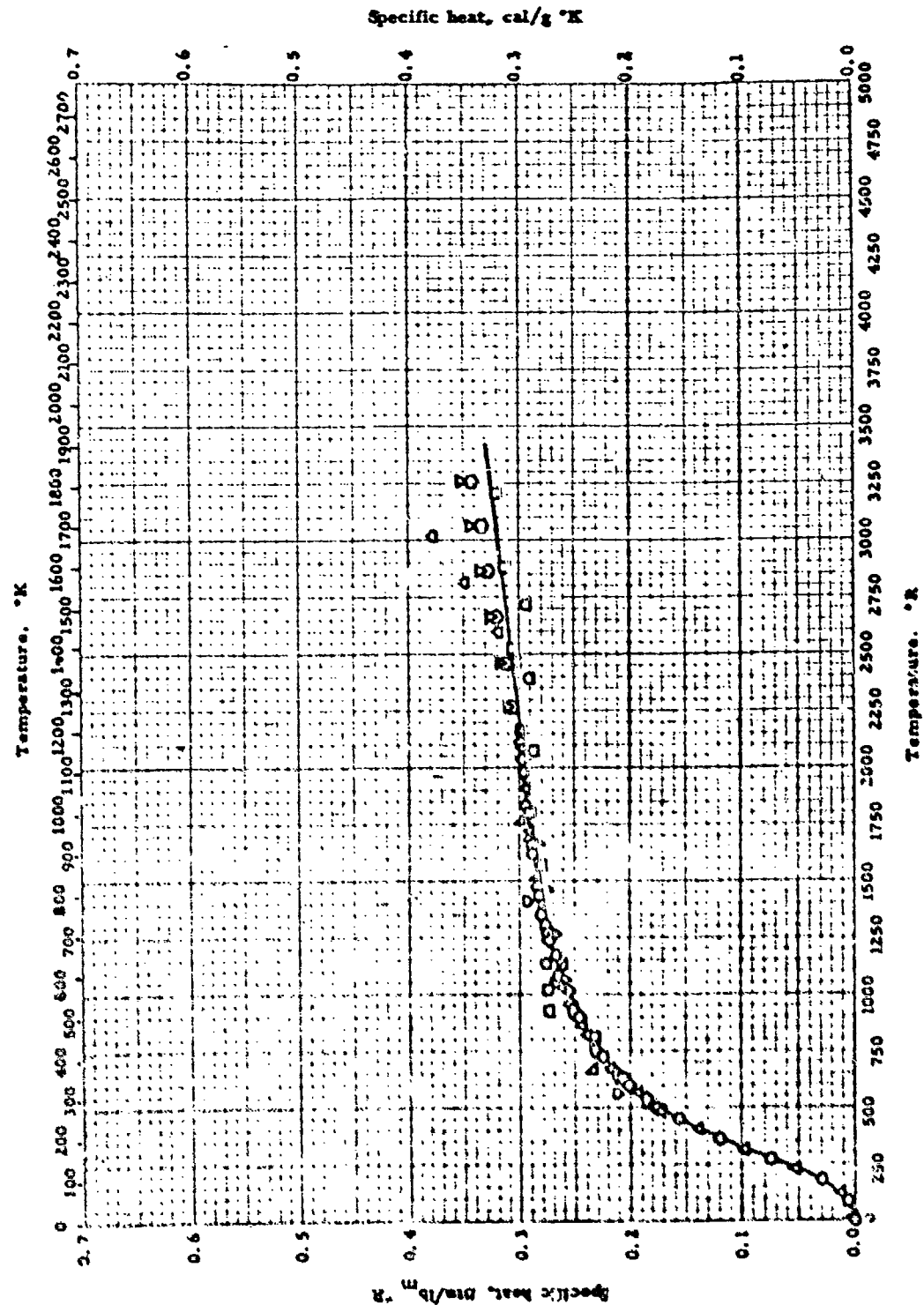
Heat of Vaporization:	Btu/lb _m	cal/g
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Heat of Sublimation:	Btu/lb _m	cal/g
○	2650 ₄₀₀₂ °R	1472 ₂₂₂₃ °K
○	8052 ₅₃₇ °R	4473 ₂₉₈ °K

PROPERTIES OF ALUMINUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
52-15	Warrenberg, H. V.	4002		Alumina, Al_2O_3	ΔH_f : from vapor pressure data by Langmuir method. p: not given	Vapor pressure data obtained at 4155-4690°R, assuming $Al_2O_3(s) + 2AlO(g) + 1/2 O_2(g)$
53-10	Ewer, L. and Searcy, A. W.	Room		α and γ phases	ΔH_f : from vapor pressure data by Kaudsen method	Prepared by dissolving 99.98% Al in reagent grade HNO_3 and igniting at 1100°C
43-14	Geller, R. F. and Bondig, K. M.	4137-4173		Alumina, Al_2O_3	MP: visual observation optical pyrometer	Sample B
45-4	Geller, R. F. and Yavortsky, P. J.	4083-4087		99.99% pure α phase; 0.004% CaO ; 0.003% SiO_2	MP: rounding of corners of pyramidal; 3 optical pyrometers	Sample C; prepared by dissolving 99.98% Al in reagent grade HNO_3 and igniting at 1100°C
45-4	Idid.	4073-4092		α phase; <0.01% ea. Ag, B, Ca, Cu, Fe, Mg, Si	MP: same as above	Sample A
45-4	Idid.	4092-4110		α phase; 0.05% C; fused and recrystallized Alumina, Al_2O_3	MP: same as above	
49-16	Trombe, F.	4182		Alumina, Al_2O_3	MP: not given	Auth. est. accuracy $\pm 2\%$
54-132	National Bureau of Standards	4155-4180		Alumina, Al_2O_3	MP: visual observation, optical pyrometer	Slotted, Measured by O. Sloman, C. D. Bopp and R. L. Towns
57-150	Oak Ridge National Lab.	937		Alumina, Al_2O_3	p: weight in air and in kerosene	
57-150	Idid.	937		Sapphire	p: same as above	
57-150	Lambertson, W. A. and Gussel Jr., F. H.	4124-4182		99.9 + % pure Al_2O_3 , Alcoa T-61 grade	MP: visual observation of material in const. temp. furnace, temp. by optical pyrometer.	



59-448

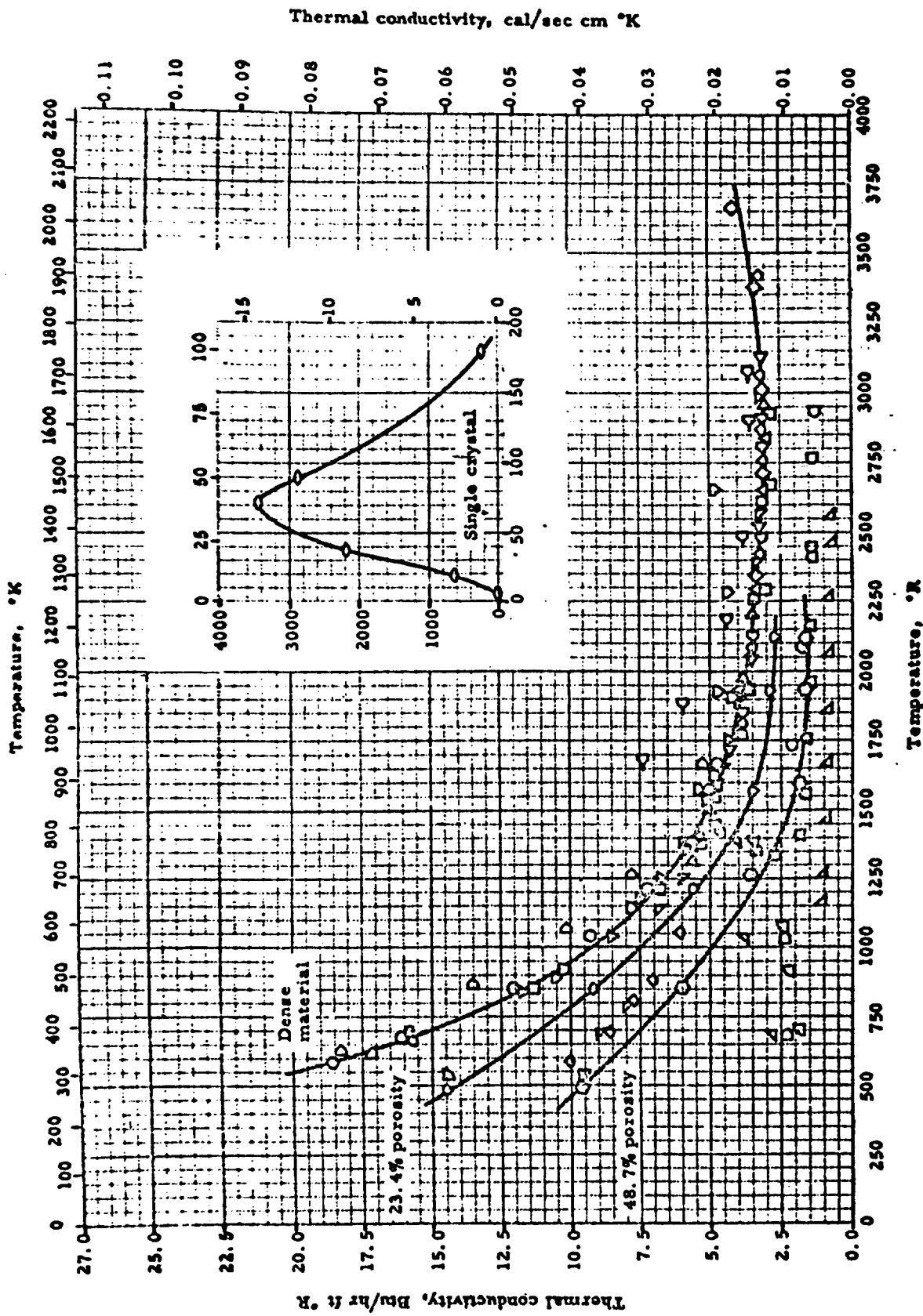
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SPECIFIC HEAT -- ALUMINUM OXIDE

SPECIFIC HEAT -- ALUMINUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
53-59	Cheney, D. C. and Furukawa, G. T.	0-2160	Corundum; synthetic sapphire; 0.01-0.02% impurities	Guarded sample up to 260°F; drop method; ice calorimeter at higher temp.	Auth. est. accuracy 0.2%, (-370 to 1160°F); slightly lower accuracy at higher temp.
43-3	Shore, C. H. and Maylar, B. F.	850-3220	100% Al ₂ O ₃ ; natural, almost colorless sapphires	Drop method	Auth. est. accuracy of heat content data ± 0.4% (298 to 1800°K)
56-24	Furukawa, G.	9-2160	α-Al ₂ O ₃ (corundum; synthetic sapphire); 99.99% pure; 0.005% ss. Si, Fe; 0.002% Cr	Adiabatic calorimeter up to 380°K; drop method; ice calorimeter between 271-1180°K	
47-17	Guinaga, E. G. and Carradell, R. J.	492-2112	α-Al ₂ O ₃ (corundum; synthetic sapphire); 0.02-0.03% impurities, mostly SiO ₂	Drop method; ice calorimeter	
98-2	Fieldhouse, L. B., Hodge, J. C. and Lang, J. L.	960-3260	Polycrystalline Al ₂ O ₃	Drop method; water calorimeter	Auth. est. accuracy of heat content data ± 0.2% above 160°C
58-2	Deid.	960-3260	Synthetic sapphire	Same as above	
56-1	Lucka, C. F. and Deem, H. W.	912-2715	Not given	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
52-33	Lucka, C. F. and Blag, G. J.	1021-1401	Not given	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
55-71	Rodriguez, E. M. and Cornet'ski, N. Z.	2472-3012	α-Al ₂ O ₃ ; 99.9% pure	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
54-21	Orian, R. A. and Murphy, W. K.	546-1415	α-Al ₂ O ₃ ; High purity corundum	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
54-65	Ewing, C. T. and Baker, B. E.	669-1761	Al ₂ O ₃ crystals	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
51-84	Orian, R. A.	492-1415	Synthetic sapphire	Drop method, ice calorimeter. Sample temp. measured by calibrated Pt-Pt Rh thermocouple	Author reports enthalpy. c_p calculated from $c_p = \frac{\Delta h}{\Delta T}$



Thermal conductivity -- ALUMINUM OXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE

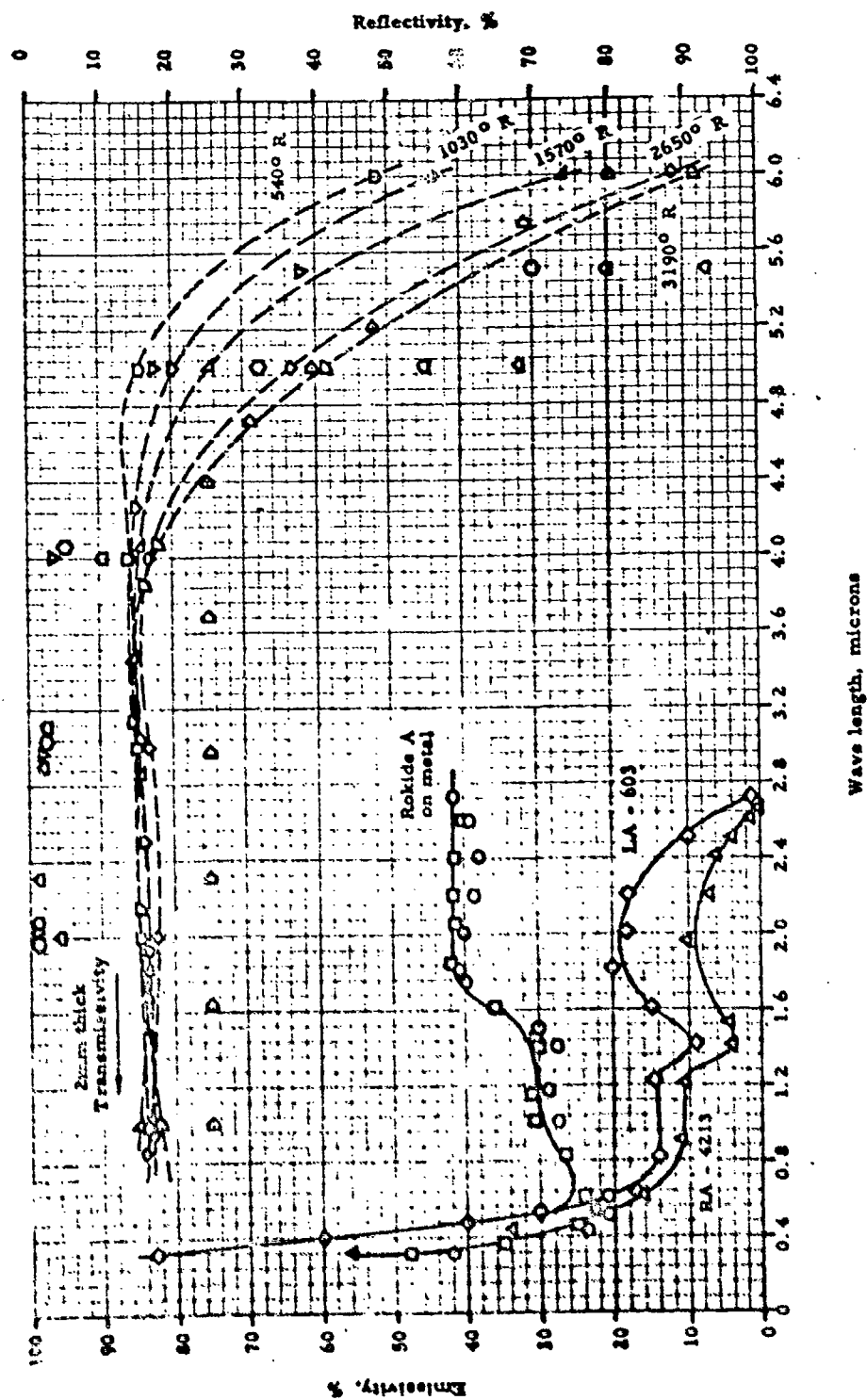
REFERENCE INFORMATION

Sp. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Franci, J. and Kingery, W. D.	54-6 53-67 52-66	564-1662	$p = 236.5 \text{ lb}_m/\text{ft}^3$; apparent porosity 0%	Comparative; rods	Slip cast from suspension of finely ground material
△	Adams, Milton	54-5 53-67	1392-2832	$p = 228.4 \text{ to } 230.3 \text{ lb}_m/\text{ft}^3$; porosity 6.35 to 7.11%	Prolate spheroid envelope	Slip cast from suspension of finely ground material
□	Kingery, W. D.	54-4 53-67	852-2922	"High density"; Al_2O_3	Radial heat flow in sphere and in cylinder	Slip cast from suspension of finely ground material
○	McQuarrie, Malcolm	54-3 52-65 53-67 52-67	2292-3660	Prepared from Norton Co. Alundum abrasive grain $38 \times 220\text{F}$; 99.44% Al_2O_3 ; 0.31% Fe_2O_3 ; 0.24% SiO_2 ; 0.01% TiO_2	Prolate spheroid envelope	Slip cast from suspension of finely ground material
○	Weebe, James L. and Seifert, Ralph L.	52-1 also 51-39	658-672	Synthetic sapphire	Comparative; rods (Armco Iron Standards)	Sample axis at 60° from "C" axis
△	Whitemore Jr., O. J.	49-1	1160-2560	99% pure; $p = 120 \text{ lb}_m/\text{ft}^3$; porosity = 53%	Flat plate with liquid calorimeter	Made from 8 mesh grain or finer; fired at 3690°R; measured by G. B. Wilkes, M.I.T.
○	Idid.	49-1	1410-2260	99% pure; $p = 195 \text{ lb}_m/\text{ft}^3$; porosity = 23%	Same as above	Made from 14 mesh grain or finer; fired at 3690°R; measured by G. B. Wilkes, M.I.T.
○	Franci, J. and Kingery, W. D.	54-2 52-38 53-65	492-2112	Prepared from Norton Co. Alundum abrasive grain $38 \times 220\text{F}$; porosity = 48.7%	Comparative; rods	Ground in steel mill and acid treated to remove Fe. Pores formed by casting with naphthalene flakes and evaporating naphthalene.
○	Idid.	54-2	492-2112	Prepared from Norton Co. Alundum abrasive grain $38 \times 220\text{F}$; porosity = 23.4%	Same as above	Same as above
○	Berman, R.	51-14	5-180	Corundum; single crystal 3 mm dia. and 60 mm long	Axial heat flow in rod, guarded heat source and sample	Tested in vacuum
▽	Francis, R. K., McLamara, E. P., and Tinkpaugh, J. R.	58-7	852-1732	97.6% Al_2O_3 ; $p = 230 \text{ lb}_m/\text{ft}^3$; identified as Western Gold and Platinum Body Al-300	Comparative; rods alumina standard	Standard supplied by W. D. Kingery
▽	Norton, F. H. and Kingery, W. D.	51-75	690-2480	Al_2O_3	Comparative; rods below 1400°R; ellipsoidal envelope above 1400°R	

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE (Cont'd)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
57-53	Charvat, F. R. and Kingery, W. D.	57-53	888-2652	Single crystal (sapphire)	Comparative; rods (Al_2O_3 polycrystalline cube standards)	Same as above
57-53	Idid.	57-53	888-2652	Polycrystalline Al_2O_3	Same as above	Same as above
53-17	Weeks, J. L. and Siefert, R. A.	53-17	618	Sapphire (axis 60° from C axis); $p = 249.6$ lb/in ²	Comparative; rods (Armco iron standard)	Tested in vacuum
58-2	Fieldhouse, L. B., Hedge, J. C. and Lang, J. L.	58-2	582-3377	Polycrystalline Al_2O_3	Radial heat flow in cylinder of stacked disks	In He atmos.
43-11	Knaapp, W. J.	43-11	670-1385	Corundum (African)	Comparative; cubes, stainless steel standard	Parallel to C axis
43-11	Idid.	43-11	670-1774	Same as above	Same as above	Normal to C axis
43-11	Idid.	43-11	705-1375	Sapphire (synthetic)	Same as above	Normal to C axis
57-150	Oak Ridge National Laboratory	57-150	546	Al_2O_3	Not given, refers to others	Sintered; measured by Q. Sieman, C. D. Hopp and R. L. Towne
57-150	Idid.	57-150	546	Sapphire	Same as above	Grain size 5-9 μ ; hot pressed at 3000 ψ at 3000 psi
58-25	Truesdale, R. S., Swica, J. J. and Tinkler, J. R.	58-25	625-1660	Alumina, Norton 38-900, p is 91% of theor.	Comparative; one inch cubes; alumina standard	Q-first heating Q-after repeated heatings
50-66	Norton, F. H. et al.	50-66	1640-3079	Al_2O_3	Oblate ellipsoidal envelope	Sintered, Auth. consider these values low
49-68	Norton, F. H., Yellow, D. M., et al.	49-68	1285-2926	Al_2O_3 Bulk $p = 217$ lb/in ² Open pores: 10/55 % Closed pores: 2.35%	Cylindrical envelope with hemispherical ends. Temp. by Pt-Rh thermocouple	Sintered
50-64	Norton, F. H. et al.	50-64	1223-3187	Al_2O_3	Prolate ellipsoid with heavy insulating cover	Sintered
51-77	Norton, F. H.	51-77	1220-2832	Al_2O_3	Ellipsoidal envelope	Auth. est. max. deviation from avg. $\pm 20\%$

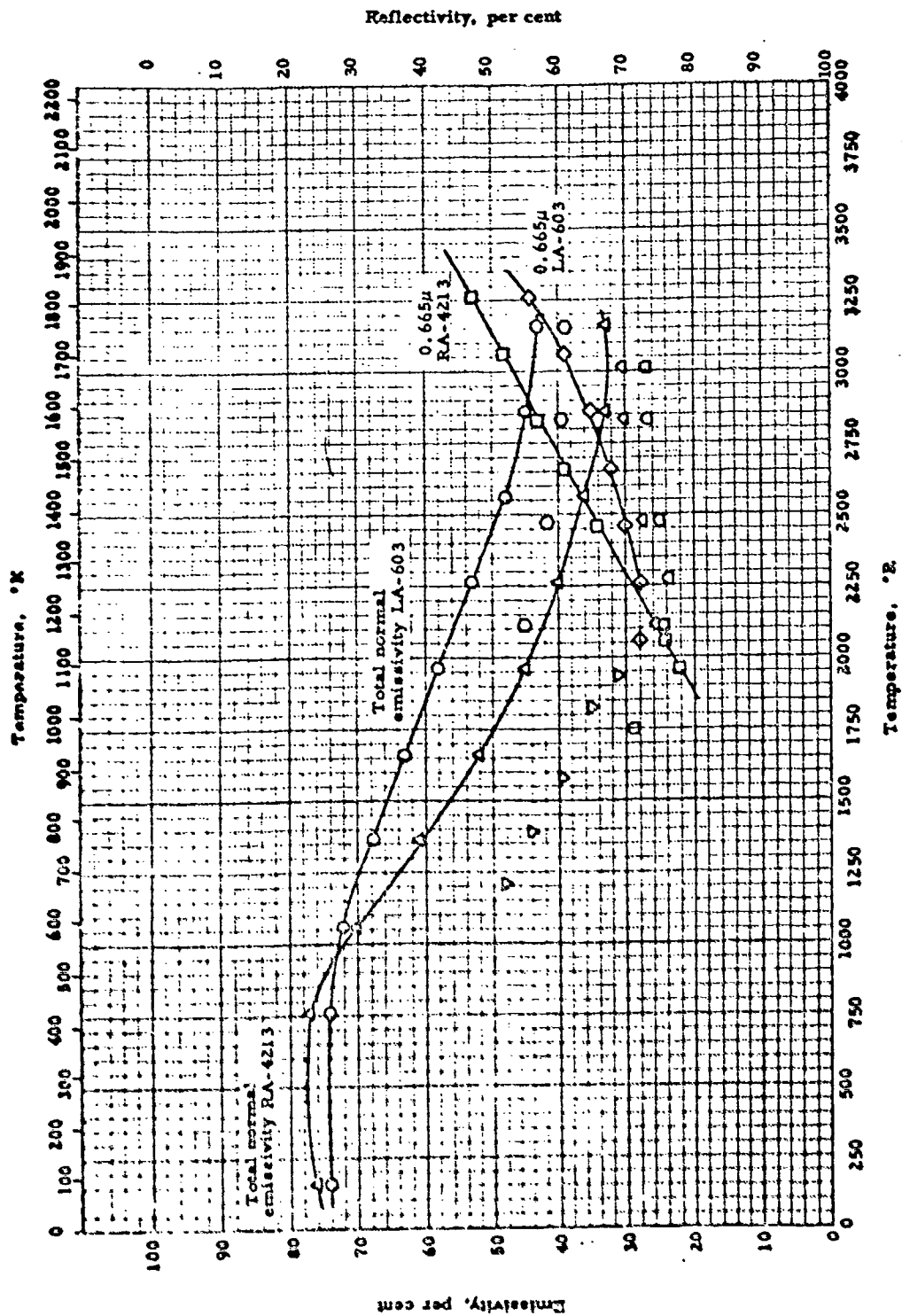


SPECTRAL EMISSIVITY -- ALUMINUM OXIDE

SPECTRAL EMISSIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
58-1	Olson, O.H. and Morris, J.	Room	Norton Boksida A on molybdenum	Spectral reflectivity at 90°; sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	
59-1	Olson, O.H. and Morris, J.	Room	Norton Boksida A on No. 446 stainless steel	Same as above	
59-1	Idid.	Room	Norton LA 603	Same as above	
59-1	Idid.	Room	Norton RA 4213	Same as above	
55-47	Kingery, W.D. and Norton, F.H.	553	Sapphire	Transmissivity meas. by Beckman IR-3 infrared spectrometer	
55-47	Idid.	1032	Same as above	Same as above	
55-47	Idid.	1572	Same as above	Same as above	
55-47	Idid.	2652	Same as above	Same as above	
57-180	Alfred Univ.	537	Sapphire	Same as above	
				Transmissivity measured with Reader infrared spectrometer double beam apparatus. Thermocouple with NaCl window. Sample temp. by optical pyrometer	Sample is 2mm thick. Data are already corrected for reflectance loss by the auth.
57-180	Idid.	1032	Same as above	Same as above	Same as above
57-180	Idid.	1572	Same as above	Same as above	Same as above
57-180	Idid.	2652	Same as above	Same as above	Same as above
57-180	Idid.	3192	Same as above	Same as above	Same as above
51-79	Gaunt, J.	Room	Synthetic sapphire	Transmissivity: not given	Sample is 3 mm thick

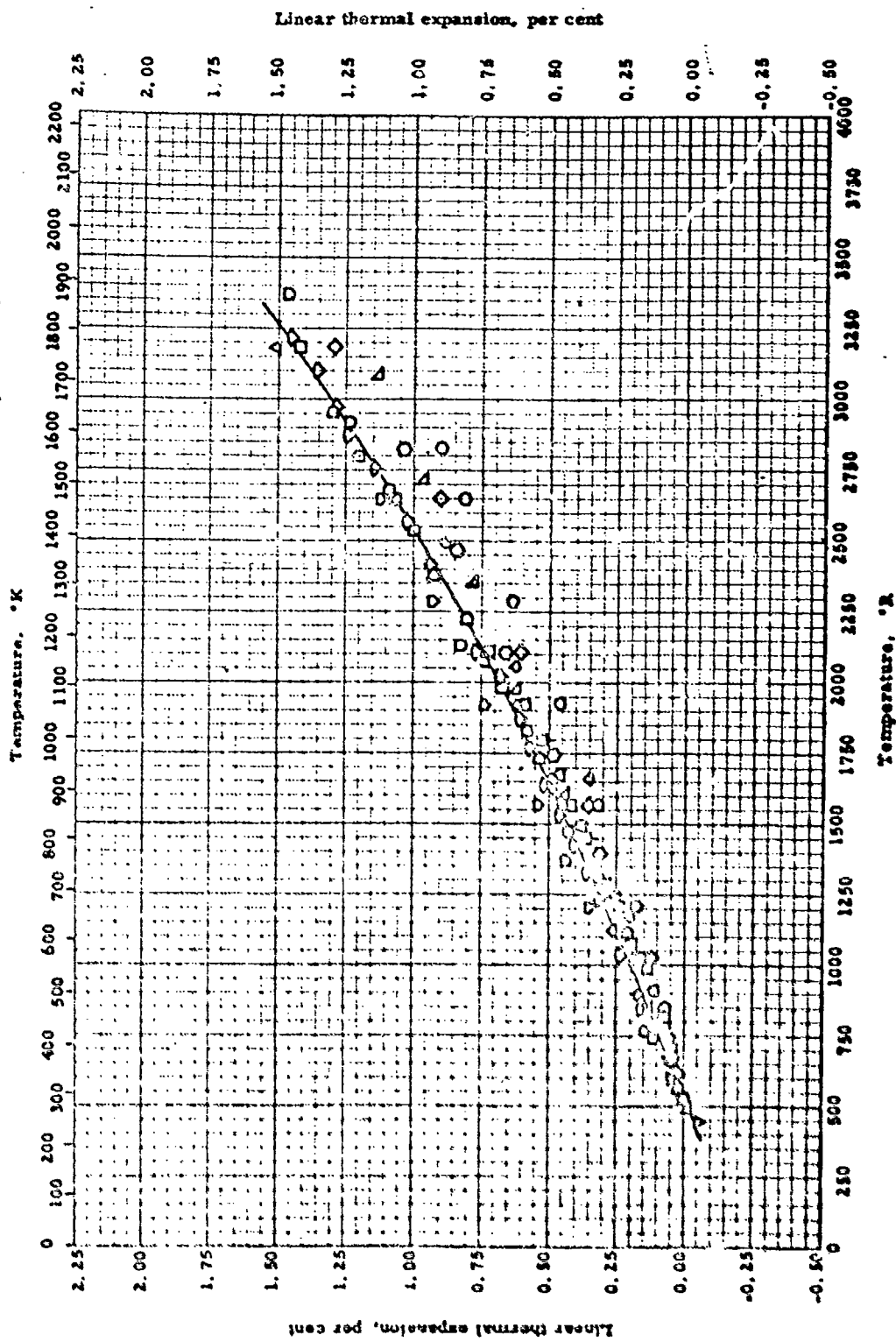


EMISSION -- ALUMINUM OXIDE

EMISSIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Olson, O.H. and Morris, J.C.	59-1	160-3160	Norton LA 603	Total normal emissivity: comparative; radiant heat flow compared with that of a black body; thermopile; sample temp. by thermocouple; in air	
□	Idid.	59-1	1960-3260	Same as above	Spectral normal emissivity at 0.65μ: comparative; surface brightness compared with that of a black body hole; disappearing filament optical pyrometer	
△	Idid.	59-	160-3160	Norton RA 4213	Total normal emissivity: comparative; radiant heat flow compared with that of a black body; thermopile; sample temp. by thermocouple; in air	
◇	Idid.	59-1	1960-3260	Same as above	Spectral normal emissivity at 0.65μ: comparative; surface brightness compared with that of a black body hole; disappearing filament optical pyrometer	
▽	Gully, A.H., Brandes, E.A., and Waterhouse, R.D.	52-81	212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	
○	Parsons, J.R.	55-86	2112-3186	Not given	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by optical pyrometer sighting on black body cavity	
○	Kingery, W.D. and Norton, F.H.	55-87	2112-3012	High density alumina	Spectral normal emissivity: comparative; surface brightness compared with that of a black body hole	
○	Idid.	55-87	1752-3012	Same as above	Spectral normal emissivity: comparative; surface brightness compared with that of a black body hole; sample temp. by thermocouple	



LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE

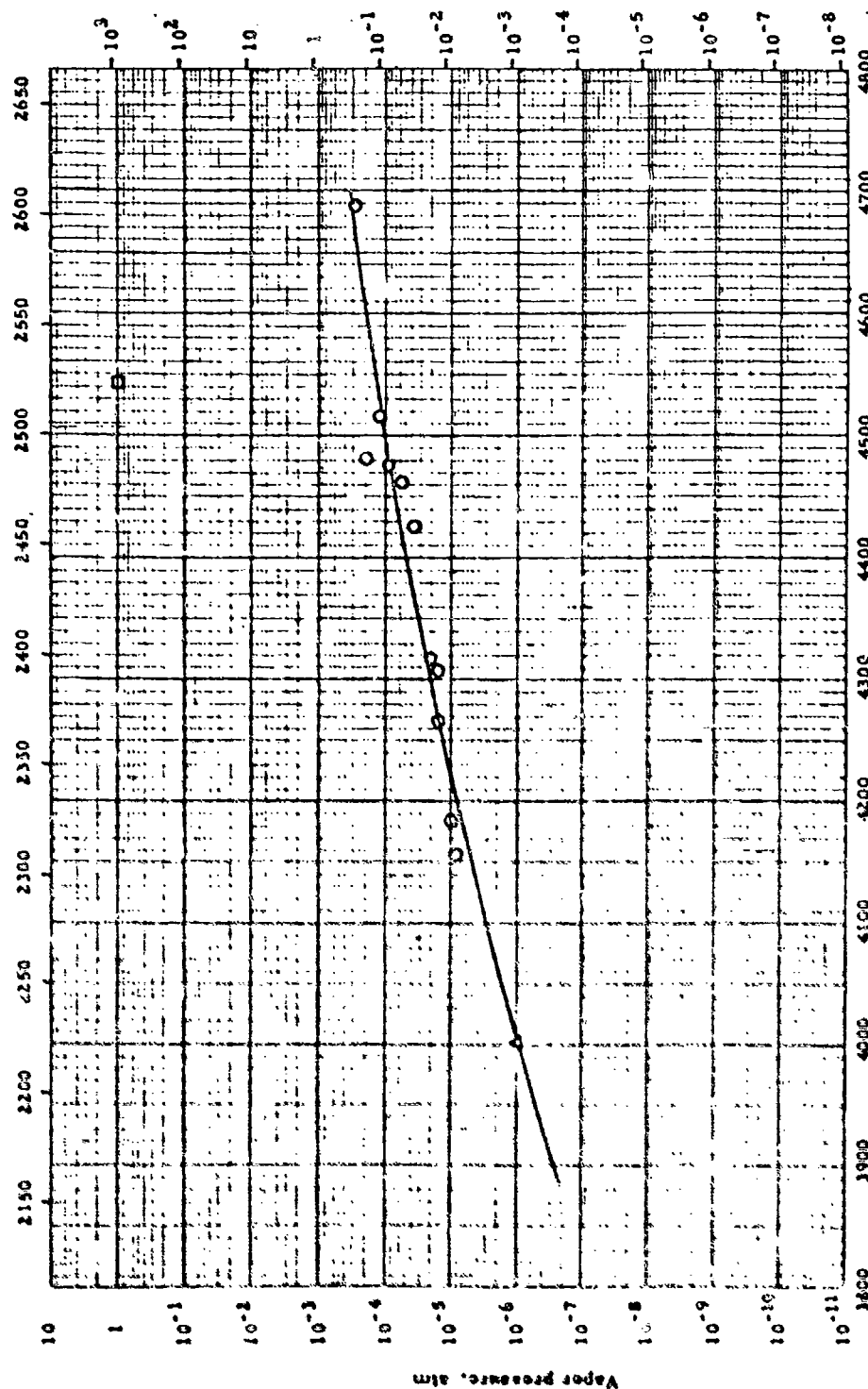
LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
32-11	Schwartz, B.	537-2532	Commercially pure (<1% impurities) fused refractory grains	Telemicroscopes sighting on sample	Slip cast, dried, fired at 1150°C, machined and refired at 1830°C 3 hr. Tested at 4°C/min rise
36-7	Whitemore, O. J. and Auld, N. M.	1032-3192	99% Al_2O_3 ; sintered; high density	Telemicroscopes sighting on pointed ends of sample	
36-7	Ibid.	1032-3192	99% Al_2O_3 ; coarse fused grains	Same as above	
36-7	Ibid.	1032-3192	88% Al_2O_3 ; clay bonded fused grains	Same as above	
49-3	Smoke, E. J.	room	From various manufacturers	Dilatometer; 8 in. sample	Points shown are to illustrate the slope at room temp.
36-10	Cibola, R. L. and Klaggy, W. D.	323-2532	Sintered; various porosities	Telemicroscopes	Ground and acid washed (Norton Co) Al_2O_3 . Gas fired 3 hr. at 1790°C. Auth. states that coeff. of exp. does not vary with porosity
54-40 also 55-19	Shervin, T. S. and Mauch, C. A.	528-1932		Silica tube dilatometer	Sintered at 3000°F; Q-cooling
57-20	Beale, R. J. and Cook, J.	526-2652	Reagent grade	X-ray back reflection	
49-16		460-3372	95.5% pure	Not given	Cast
49-16		528-1932	99% pure	Same as above	Same as above
49-16		460-672	Pure	Same as above	Same as above
57-62	Mauer, F. A. and Bole, L. H.	492-3084	Commercial grade: 0.30% Na ₂ O; 0.025% SiO_2 ; 0.04% Fe_2O_3 ; 0.002% TiO_2 ; 1.2% H_2O	X-ray diffraction	Test run in He atmos.
26-2	Fielthouse, L. B., Seiler, J. C. and Lang, J. L.	552-2553	Aluminum Oxide - Polycrystalline	Telemicroscopes sighting on sample	
58-2	Ibid.	535-3206	Synthetic Sapphire	Same as above	
58-25	Truesdale, R. S., Swica, J. J. and Tinkling, J. R.	760-2460	Alumina	Dilatometer	Alumina grain size 5-9 μ . Hot pressed at 3000°F and 3000 psi, density: 91% of theoretical

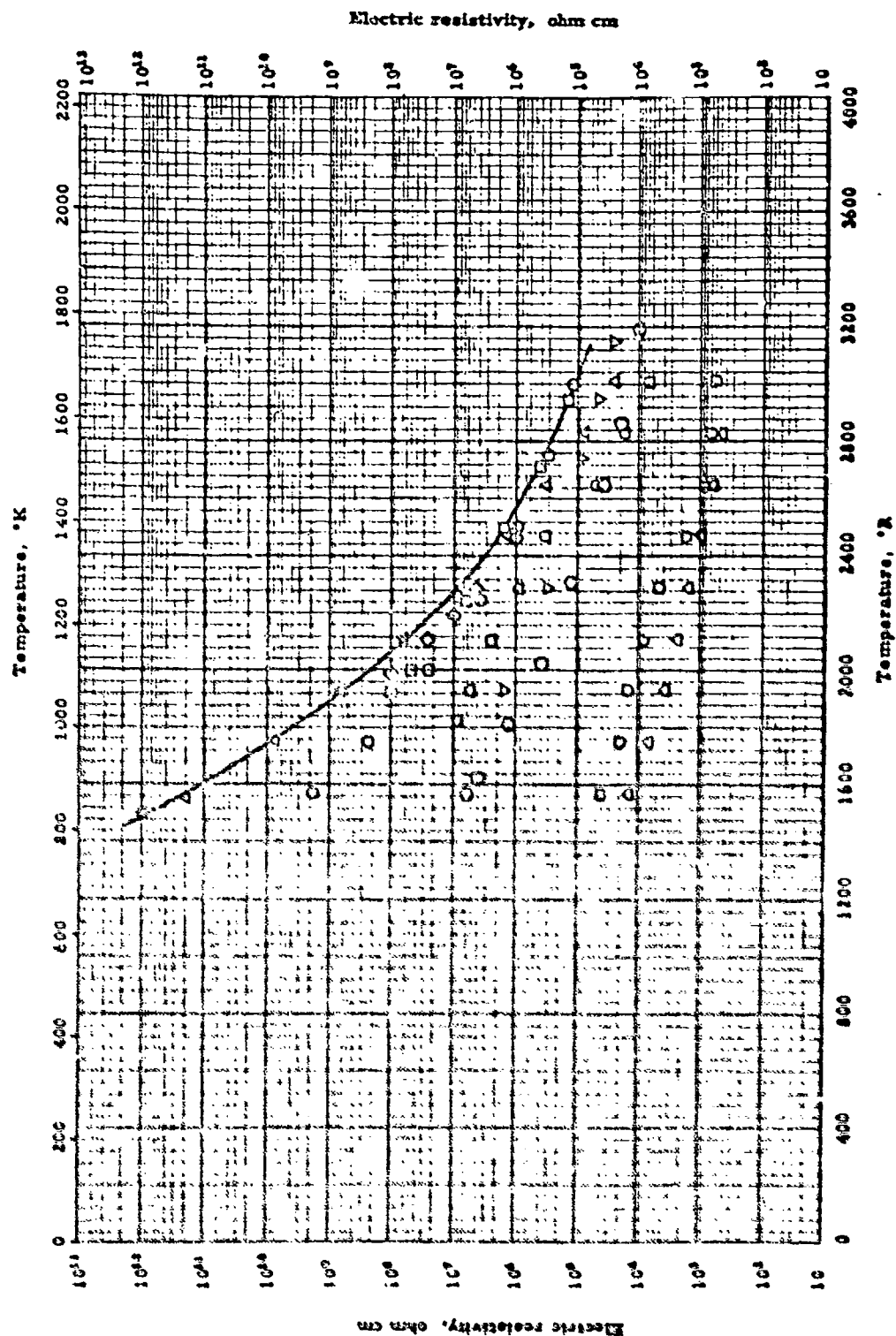
Temperature, °K

Vapor pressure, mm Hg



Temperature, °K

VAPOR PRESSURE -- ALUMINUM OXIDE



ELECTRIC RESISTIVITY -- ALUMINUM OXIDE

ELECTRIC RESISTIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

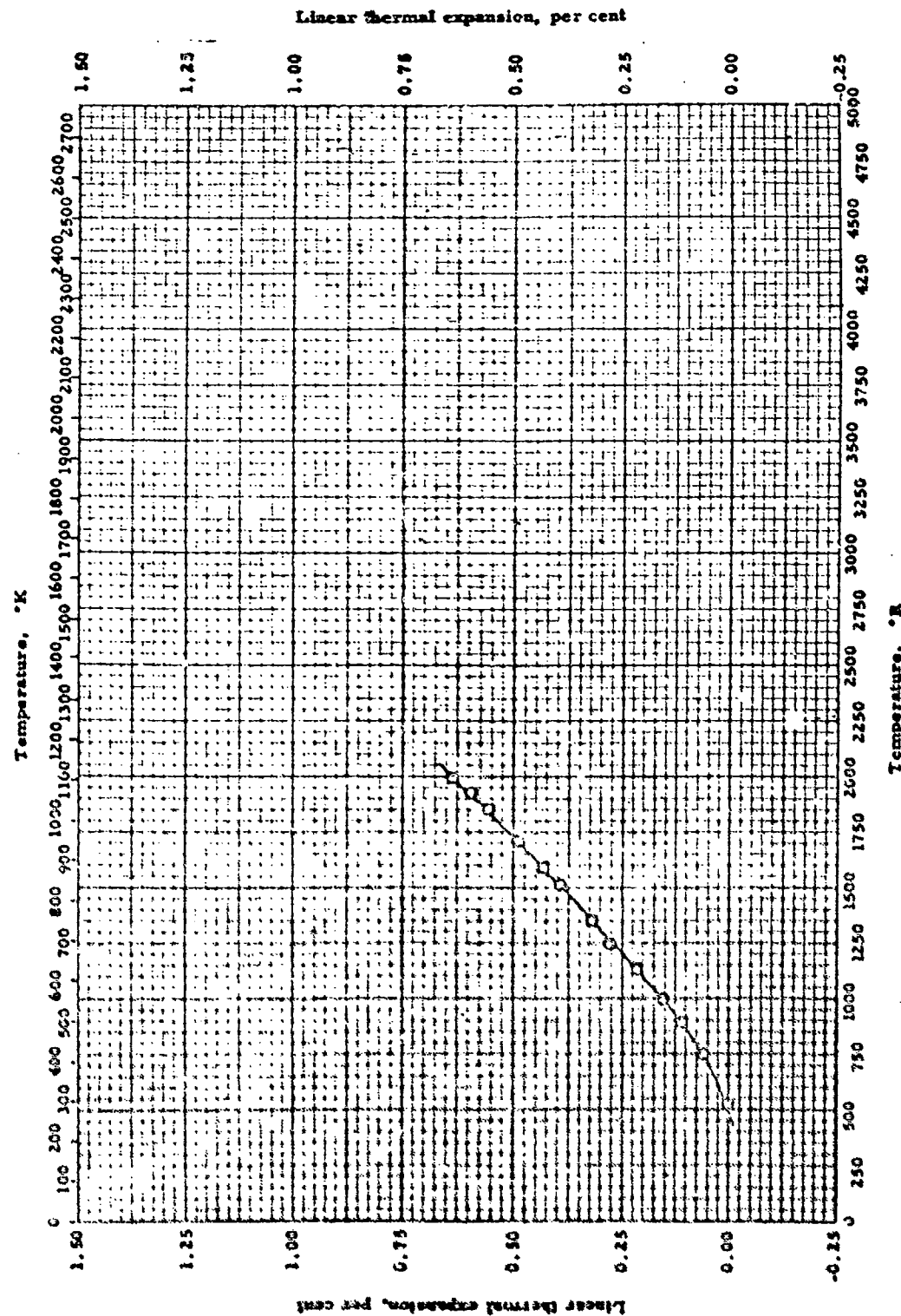
	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wachtman, J. B. and Maxwell, L. H.	53-146	1572-3006	Sapphire	Meas. by winding 0.5 in. wide strips of Pt around rods at 1 in. distance, with 200 v. DC applied	Preheated to 1400°C, undeformed
□	Ibid.	53-146	1925-3000	Same as above	Same as above	Same as above, but another sample
△	Heidt, K. and Haase, G.	54-136	1499-3191	Al ₂ O ₃ , α phase. Total impurities <0.03%	For R = 10 ⁴ - 10 ⁹ ohm: electrometer was used. For R < 10 ⁴ : potential drop	Sintered, 99.99% Al + triple distilled H ₂ O → Al ₂ O ₃ - Bayerite Heated under <10 ⁻⁴ atm. Compressed by hand; shrinkage when fired up to 35%. Electrometer accuracy ± 20%. Potential drop accuracy ± 5%. Ohm's law holds.
◇	Regener, M.	40-20	1988-2292	Al ₂ O ₃	Potential drop. Sample temp. by Pt-Rh thermocouple	1 cm cube samples, platinized faces. Auth. est. accuracy order of magnitude only
▽	Henkel, J. R. and Haury, E. G.	53-95	1932-3156	Al ₂ O ₃ , porosity = 27%	Wheatstone bridge, with cathode-ray null indicator	Acid treated Al ₂ O ₃ , fired 10 hr. at 1500°C
○	Ibid.	53-95	1572-3192	Al ₂ O ₃	Same as above	Calculated Al (OH) ₃ , fired 10 hr. at 1800°C
○	Chloebach, V. E. F. and Haury, E. G.	53-94	1824-3012	99% Al ₂ O ₃ , pyrometric cone equivalent 41-42, porosity = 24%	Wheatstone bridge at 10v and 945 cps	Meas. commercial material. Auth. est. accuracy ± 10% in megohm range, ± 4% in 51 ohm range, ± 3% in 100 ohm range. Fired, cast at 1930°C
○	Ibid.	53-94	1572-2632	Alumina, apparent porosity = 3.1%	Same as above	Fused, cast at 1940°C
○	Ibid.	53-94	1572-3012	Alumina, apparent porosity = 4.2%	Same as above	

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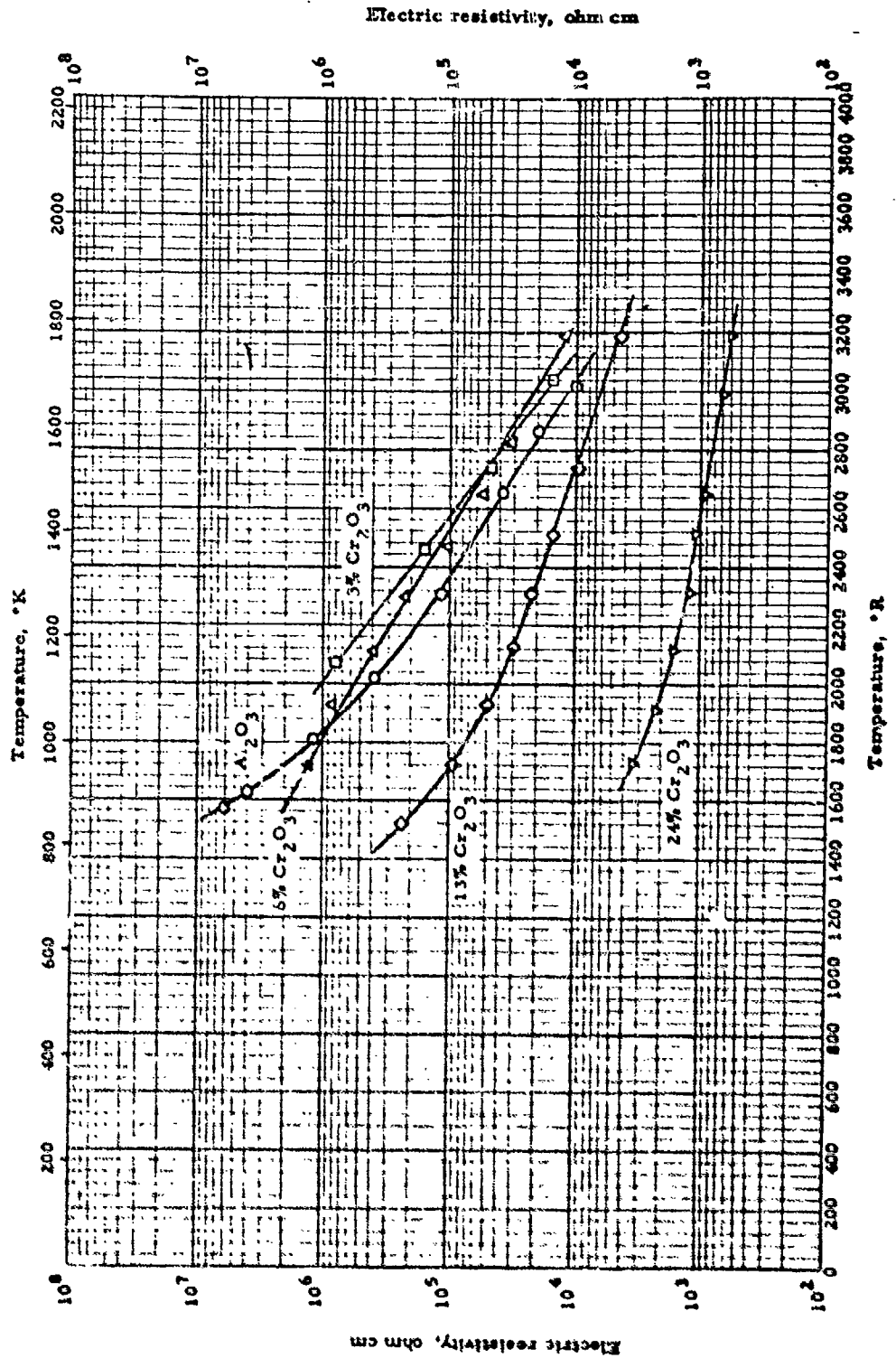


LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + CHROMIUM OXIDE

LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + CHROMIUM OXIDE

REFERENCE INFORMATION

57m bol	Investigator	R.L.	Range, °F	Material Composition	Test Method	Remarks
0	Shavlin, T. S. and Hauck, C. A.	54-60 also 55-59	528-1932	10% Cr ₂ O ₃	Silica tube dilatometer	Sintered at 3000°F
□	Ibid.	54-60 also 55-59	528-1990	20% Cr ₂ O ₃	Same as above	Same as above



ELECTRIC RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM OXIDE

ELECTRIC RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wardner, J. R., and Hearry, E. C.	53-95	1372-3192	100% Al_2O_3 ; 0% Cr_2O_3	Wheatstone bridge	Oxides obtained by calcining the coprecipitated hydroxides of aluminum and chromium. Fired 10 hr. to 1500°C
□	Did.	53-95	2076-3138	97% Al_2O_3 ; 3% Cr_2O_3	Same as above	Same as above
△	Did.	53-95	1716-3192	94% Al_2O_3 ; 6% Cr_2O_3	Same as above	Same as above
◇	Did.	53-95	1316-3192	87% Al_2O_3 ; 13% Cr_2O_3	Same as above	Same as above
▽	Did.	53-95	1736-3192	76% Al_2O_3 ; 24% Cr_2O_3	Same as above	Same as above

DENSITY -- ALUMINUM OXIDE + URANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, 79% alumina . .	286 lb _m /ft ³	4.58 g/cm ³
Melting Point		
Heat of Fusion		
Heat of Vaporization . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
O	275.5 ± 0.5	4.415 ± 0.015
□	286	4.58

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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DENSITY -- ALUMINUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Sym Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Belle, J. and Jones, L. J.	57-190	Room	79% Al ₂ O ₃ ; 21% U ²³⁵ O ₂	p: not given	Mixed enriched UO ₂ and Fisher Al ₂ O ₃ powder, dry milled 16 hr., granulated with 1% PVA and water, drying 6.2% Sterotex added, pressed at 27,400 psi, sintered 14 hr. at 1750°C in H ₂ atm.
Q	Idid.	57-190	Room	Same as above	p: computed from x-ray measurements of lat- tice	Same as above

Symbol	Material Composition, % by Wt				Mole Ratio	Melting Point	
	Al ₂ O ₃	Nb ₂ O ₅	ThO ₂	BeO	ZrO ₂	°R	°K
○	60.25	39.75				3210	1783
	53.20	46.80				3183	1768
□	53.68		33.36	12.96	4:1:4	3748 ± 2	2082 ± 1
	60.70		39.30		4:1	3935 ± 5	2186 ± 3
	53.67		46.33		3:1	3938 ± 8	2188 ± 5
◇	54.07			13.26	32.67	3678 ± 18	2043 ± 10

MELTING POINT -- ALUMINUM OXIDE + OTHER OXIDES

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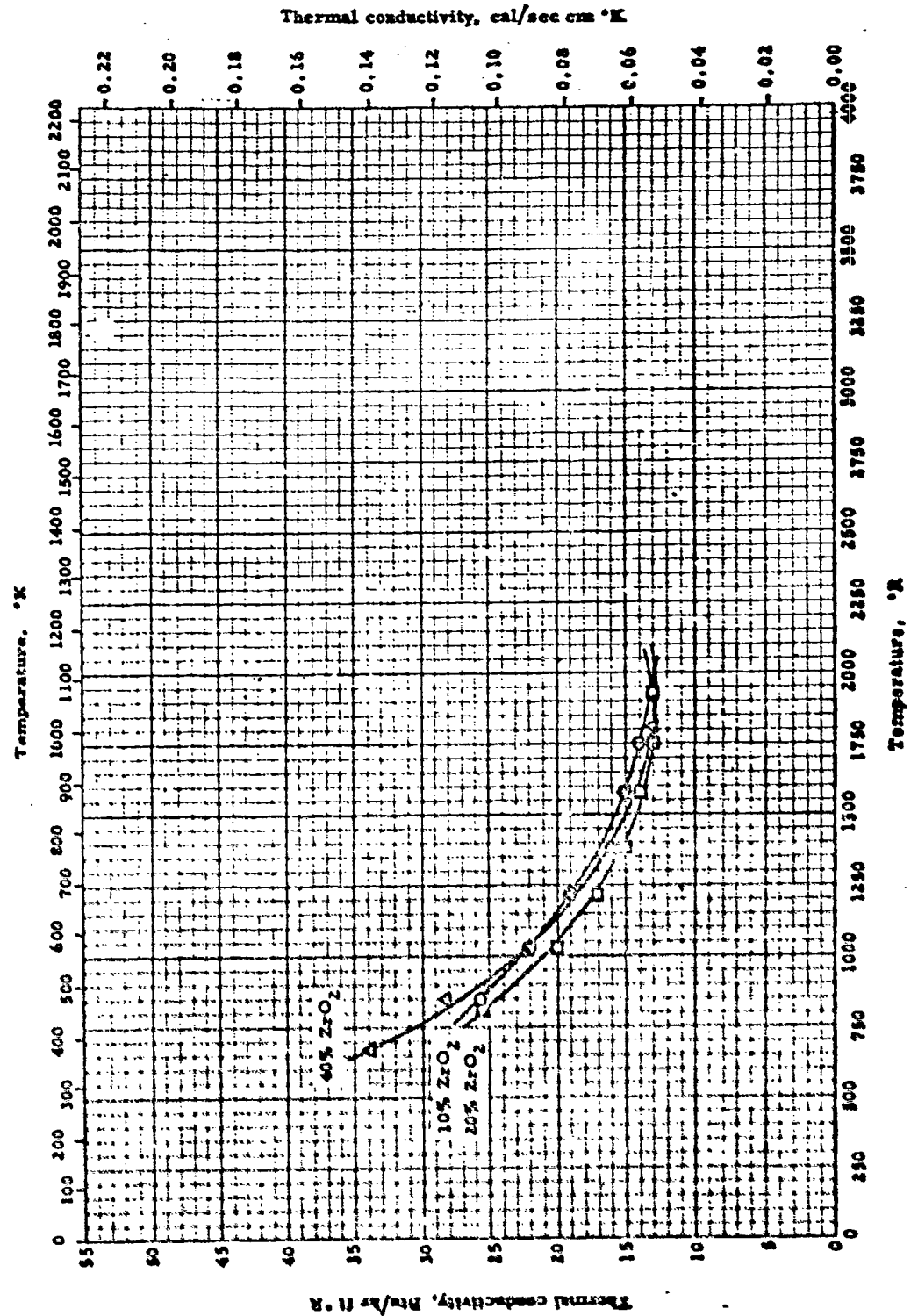
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MELTING POINT -- ALUMINUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
32-31	Durbin, E. A. and Herman, C. O.	3093-3210	$Al_2O_3 + Nb_2O_5$	Measured approximate fusion temperature during sintering	Prepared from 99.5+ % pure Al_2O_3 and 99.9% pure Nb_2O_5
34-132	National Bureau of Standards	3746-3750	$4Al_2O_3 + ThO_2 + 4BeO$	Visual observation, optical pyrometer	Average of 3-5 tests. Author states precision $\pm 2\%$
34-132	Idid.	3930-3940	$4Al_2O_3 + ThO_2$	Same as above	Same as above
34-132	Idid.	3660-3697	$2Al_2O_3 + ZrO_2 + 2BeO$	Same as above	Same as above



Thermal conductivity -- ALUMINUM OXIDE - ZIRCONIUM OXIDE SINTER

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THERMAL CONDUCTIVITY -- ALUMINUM OXIDE - ZIRCONIUM OXIDE SINTER

REFERENCE INFORMATION

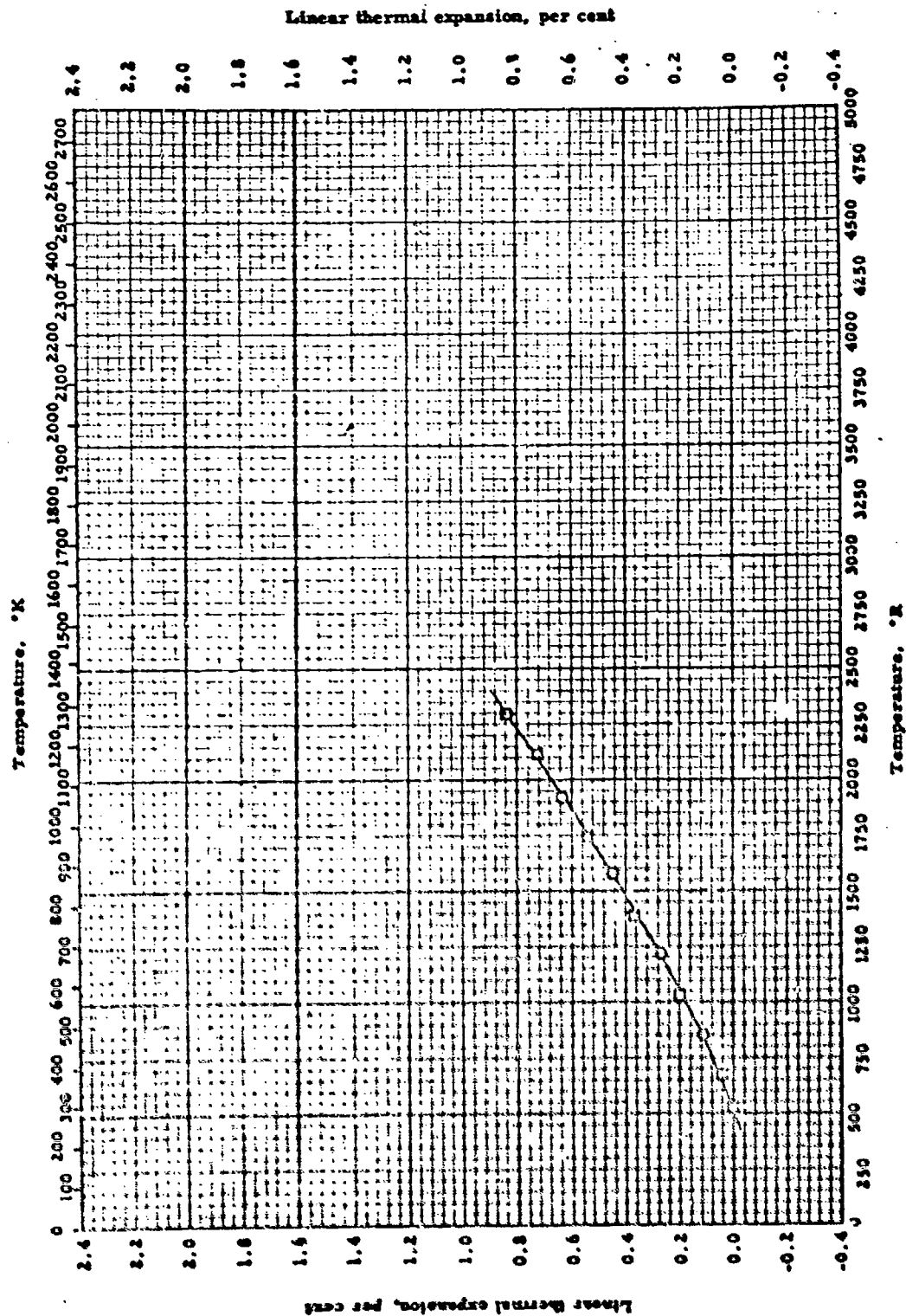
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
55-47	Kingery, W. D., and Norton, F. H.	852-1932	90% Al_2O_3 ; 10% ZrO_2	Comparative; rods	Sintered
55-47	Ibid.	807-1932	80% Al_2O_3 ; 20% ZrO_2	Same as above	Same as above
55-47	Ibid.	672-1866	60% Al_2O_3 ; 40% ZrO_2	Same as above	Same as above

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LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

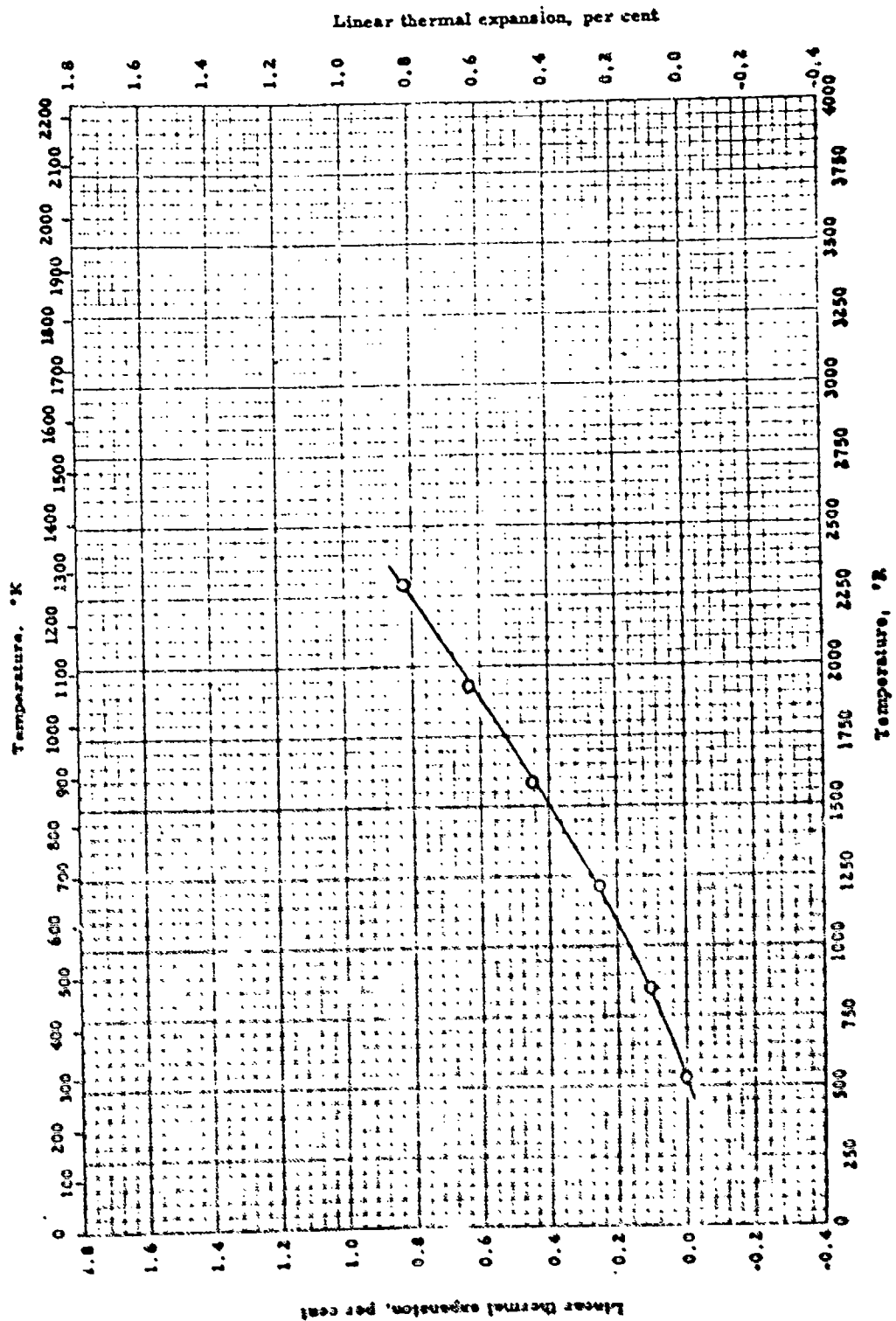
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
46-4	Celler, R. F., Yavorsky, R. J. et al.	528-2292	2.52% MgO; 5.29% BeO; prepared from 97% pure MgO, 99.7% pure BeO, 99.9% pure Al ₂ O ₃	Interferometer	(MgO · BeO · 4Al ₂ O ₃)
46-4	IMA,	528-2292	41.29% BeO; 16.64% MgO; prepared from 97% pure MgO, 99.7% pure BeO, 99.9% pure Al ₂ O ₃	Same as above	(MgO · 4BeO · Al ₂ O ₃)

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LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + THORIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Sym Eq	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Geller, R. N., Yavorsky, P. J., Strizhma, B. L., and Creamer, A. S.	46-4	528-2292	34.22% ThO ₂ , 12.96% BeO; prepared from 99.7% pure BeO, 99.4% pure Al ₂ O ₃ , 99.4% pure ThO ₂ (calcined)	Interferometer	(4BeO · 4Al ₂ O ₃ · ThO ₂) Sintered

PROPERTIES OF BERYLLIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	189 lb _m /in ³	3.03 g/cm ³
Melting Point.	4905° R	2725°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /in ³	g/cm ³
○	185	2.96
□	189	3.03
◇	92.4	1.48
▽	192	3.08
○	176	2.8
△	177 ± 2	2.84 ± 0.03
<u>Melting Point:</u>	°R	°K
△	5118	2843
△	4905	2725

Heat of Fusion: Btu/lb_m cal/g

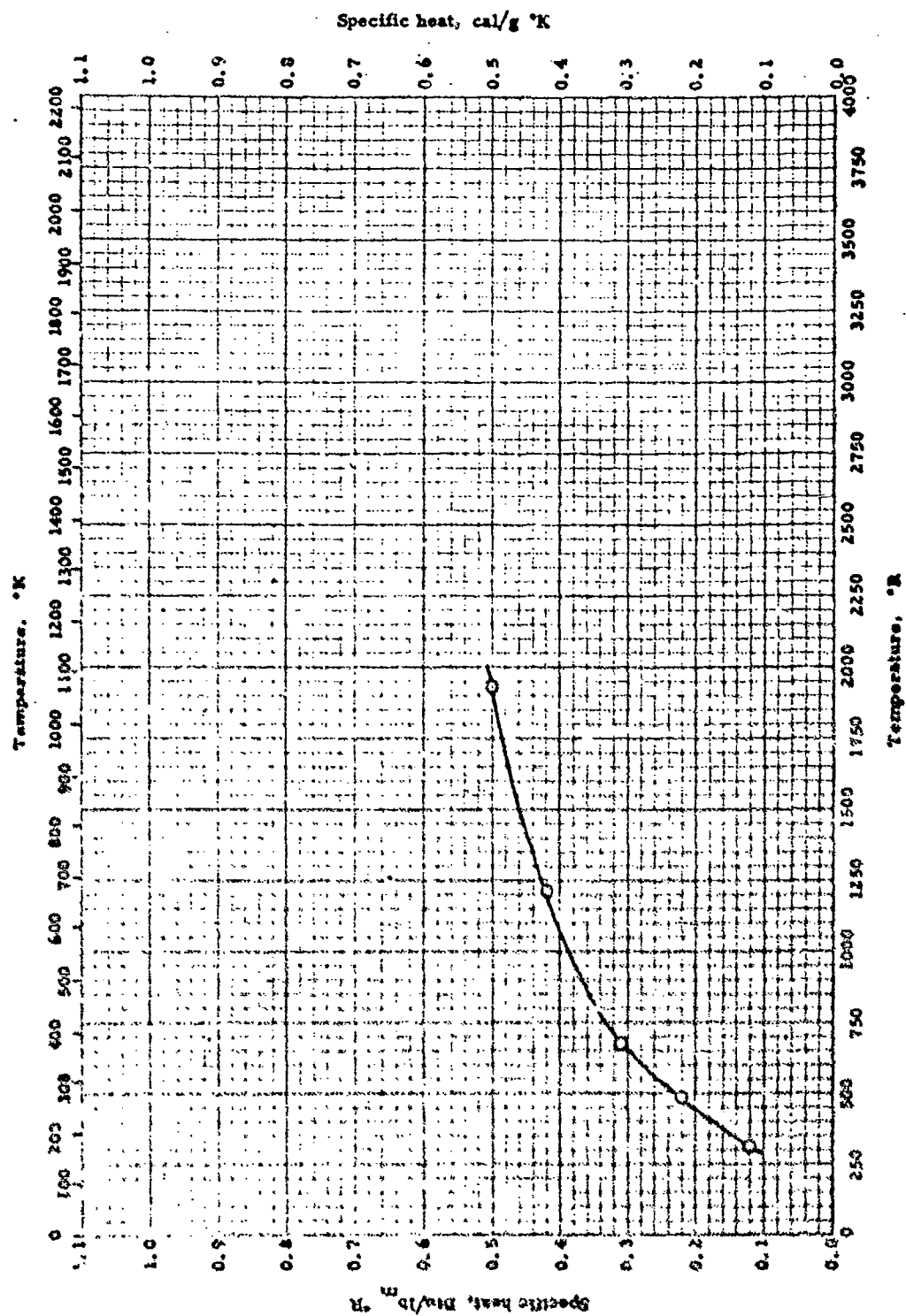
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gargler, J. J.	50-10	Room	35.66% Be; 63.24% O ₂ ; 0.08% free C	p: weight in air and in distilled water	Fabricated by hot pressing in graphite mold
□	Ibid.	50-10	Room	Same as above	p: computed from X-ray measurements of lattice	Same as above
△	Trombe, F.	49-16	5118	Not given	MF: not given	
▽	Johnson, P. D.	50-37	Room	<1.0% Ca; <0.01% ea. Mg, Na, Si	p: computed from x-ray measurements of lattice	From Be hydroxide; calcined 1 hr. at 1000°C, pressed at 52000 psi
◇	Ibid.	50-37	Room	Same as above	p: not given	Same as above
○	Ibid.	50-37	Room	Same as above	p: same as above	From Be hydroxide; calcined 1 hr. at 1000°C; fired at 1900-2100°C
□	Oak Ridge National Laboratory	57-150	537	BeO	p: weight in air and in kerosene	By O. Sisman, C. D. Bopp and R. L. Towns
△	National Bureau of Standards	54-132	4905	BeO	MP: visual observation, optical pyrometer	Average of 3 - 5 tests; auth. est. accuracy ± 2%

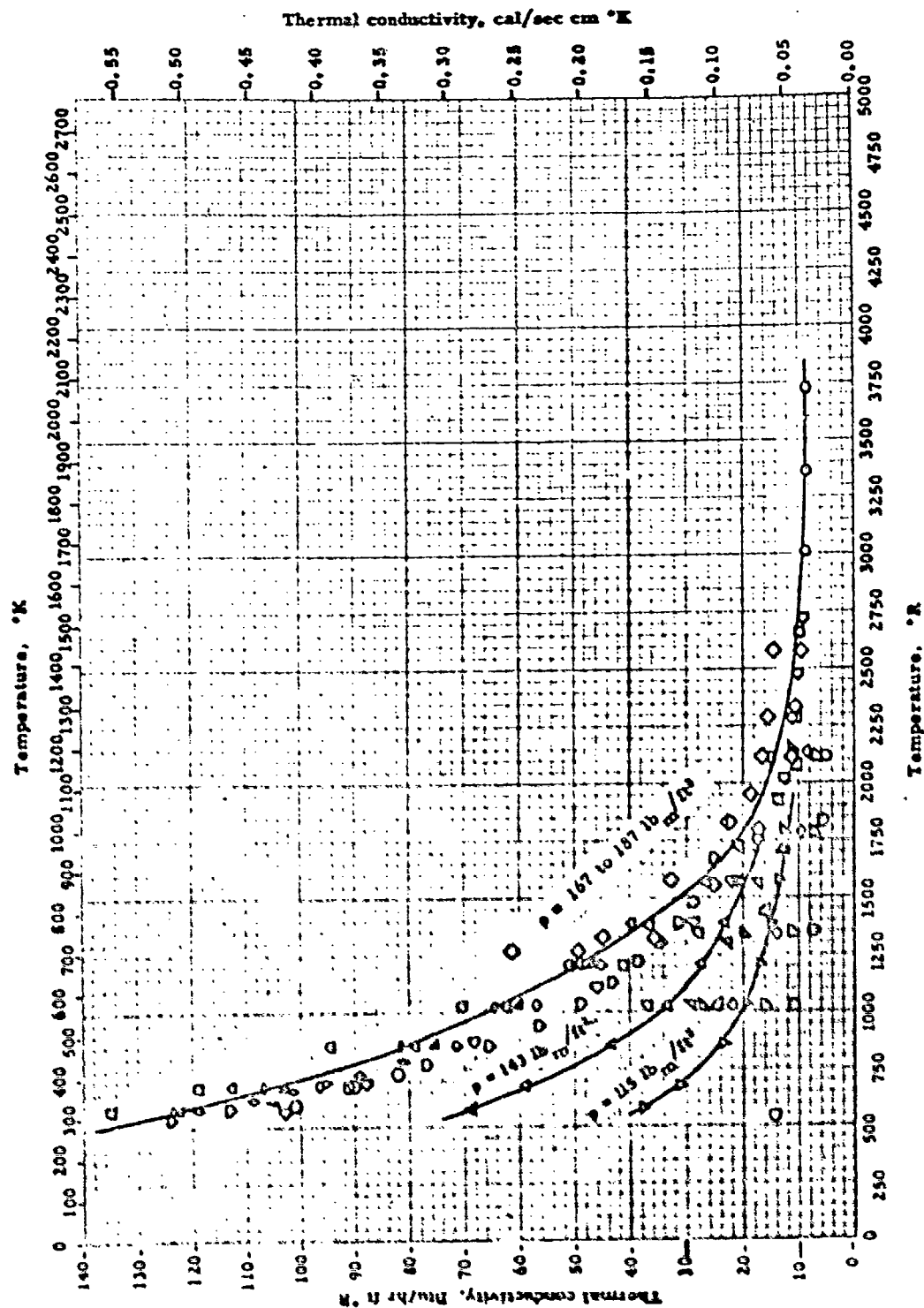


SPECIFIC HEAT -- BERYLLIUM OXIDE

SPECIFIC HEAT -- BERYLLIUM OXIDE

REFERENCE INFORMATION

<u>Sym</u> <u>Sci</u>	<u>Investigator</u>	<u>Ref.</u>	<u>Range, °R</u>	<u>Material Composition</u>	<u>Test Method</u>	<u>Remarks</u>
O	Reactor Handbook	55-152	512-1932	Beryllia, BeO	Not given	Not original data. Source not indicated



THERMAL CONDUCTIVITY - BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE

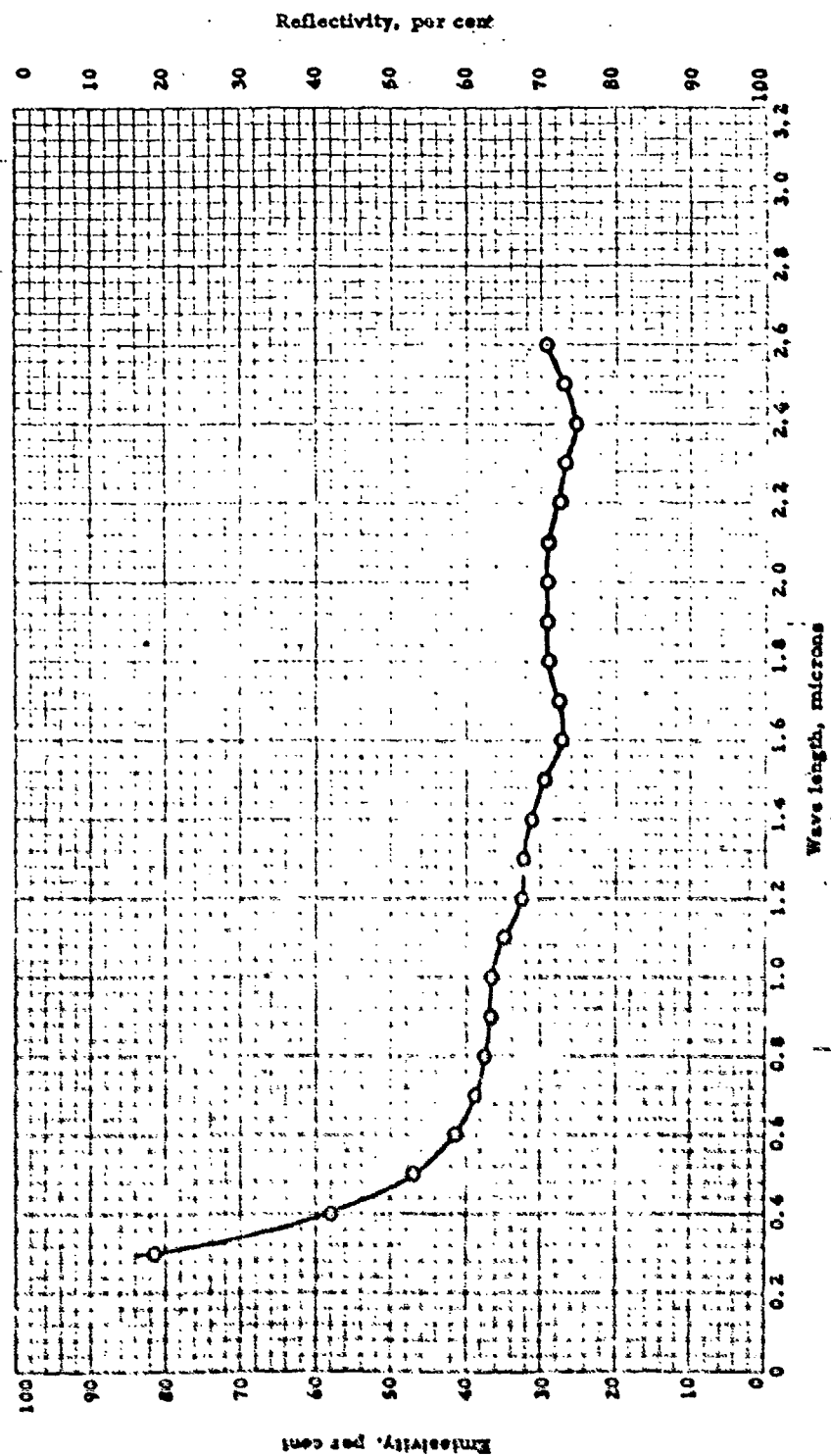
REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
Q	McQuarrie, Malcolm	2292-2732	99.71% BeO; 0.18% MgO; 0.08% Al ₂ O ₃ ; 0.01% Fe ₂ O ₃ ; prepared from refractory grade (220 mesh) BeO	Prelate spheroid envelope	Prepared by slip casting finely ground material
Q	Adams, Milton	1212-2652	$\rho = 168 \text{ lb}_m/\text{ft}^3$; porosity = 9.7%	Prelate spheroid envelope	Prepared by slip casting finely ground material
Q	Kingery, W. D. and Norton, J. H.	1366-2660	Prepared by KAPL; $\rho = 174 \text{ lb}_m/\text{ft}^3$	Comparative; rods	Prepared by slip casting finely ground material
Q	Franci, J. and Kingery, W. D.	582-1572	$\rho = 167 \text{ lb}_m/\text{ft}^3$ Zero apparent porosity	Comparative; rods	
Q	New Jersey Ceramic Research Station	579-791	$\rho = 185 \text{ lb}_m/\text{ft}^3$	Comparative; rods (Cu standard)	Hot pressed; tested in vacuum
Q	Scholes, William A.	588-725	"100% BeO"; $\rho = 185.3 \text{ lb}_m/\text{ft}^3$	Comparative; rods (Cu standard)	Hot pressed
Q	Weeks, James L. and Giffert, Ralph A.	618	$\rho = 187 \text{ lb}_m/\text{ft}^3$	Comparative; rods (Armco iron standard)	Hot pressed, tested in vacuum
Q	Powell, R. W.	582-1212	$\rho = 175 \text{ lb}_m/\text{ft}^3$	Comparative; rods (iron standard)	Hot molded
Q	Idid.	682-1212	$\rho = 170 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
Q	Idid.	582-1392	$\rho = 176 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
Q	Idid.	582-1232	$\rho = 188 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
Q	Idid.	582-1572	Over 99% BeO, main impurity Al ₂ O ₃ ; $\rho = 143 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 1750 °C
Q	Idid.	582-1572	Over 99% BeO, main impurity Al ₂ O ₃ ; $\rho = 115 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
Q	Zimmerman, D. A. and Glenside, D. C.	546-1838	Impurities <0.2%; $\rho = 163 \text{ lb}_m/\text{ft}^3$	Axial heat flow in rod; guarded heat source and sample	Hot pressed; fired at 1700 °C. Auth. est. accuracy $\pm 3\%$

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
1	Nelson, H. R.	57-176	1032-2112	$\rho = 118 \text{ lb}_m/\text{ft}^3$	Axial heat flow in rod	Prepared from 200 mesh refractory grade powder by dust pressing
2	Ibid.	57-176	1032-2112	$\rho = 139 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
3	Ibid.	57-176	1032-2112	$\rho = 125 \text{ lb}_m/\text{ft}^3$	Same as above	Prepared from 200 mesh refractory grade powder by extrusion of blanks fired at 2800°F and 3100°F
4	Ibid.	57-176	1032-2112	$\rho = 136 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
5	Ibid.	57-176	1032-2112	$\rho = 132 \text{ lb}_m/\text{ft}^3$	Same as above	Prepared from 200 mesh refractory grade powder by hot pressing
6	Ibid.	57-176	1032-1572	$\rho = 140 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
7	Ibid.	57-176	1032-2112	$\rho = 179 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
8	Morton, F. H. and Kingery, W. D.	51-75	580-2700	99.6% BeO, $\rho = 165 \text{ lb}_m/\text{ft}^3$ 10% total porosity	Ellipsoidal envelope, temp. by thermocouple	Slip cast Auth. est. accuracy $\pm 8\%$
9	Oak Ridge Natl. Laboratory	57-150	546	BeO	Not described here, refer to others	Auth. est. accuracy $\pm 10\%$ Measured by O. Sieman, C. B. Bopp and R. L. Towne

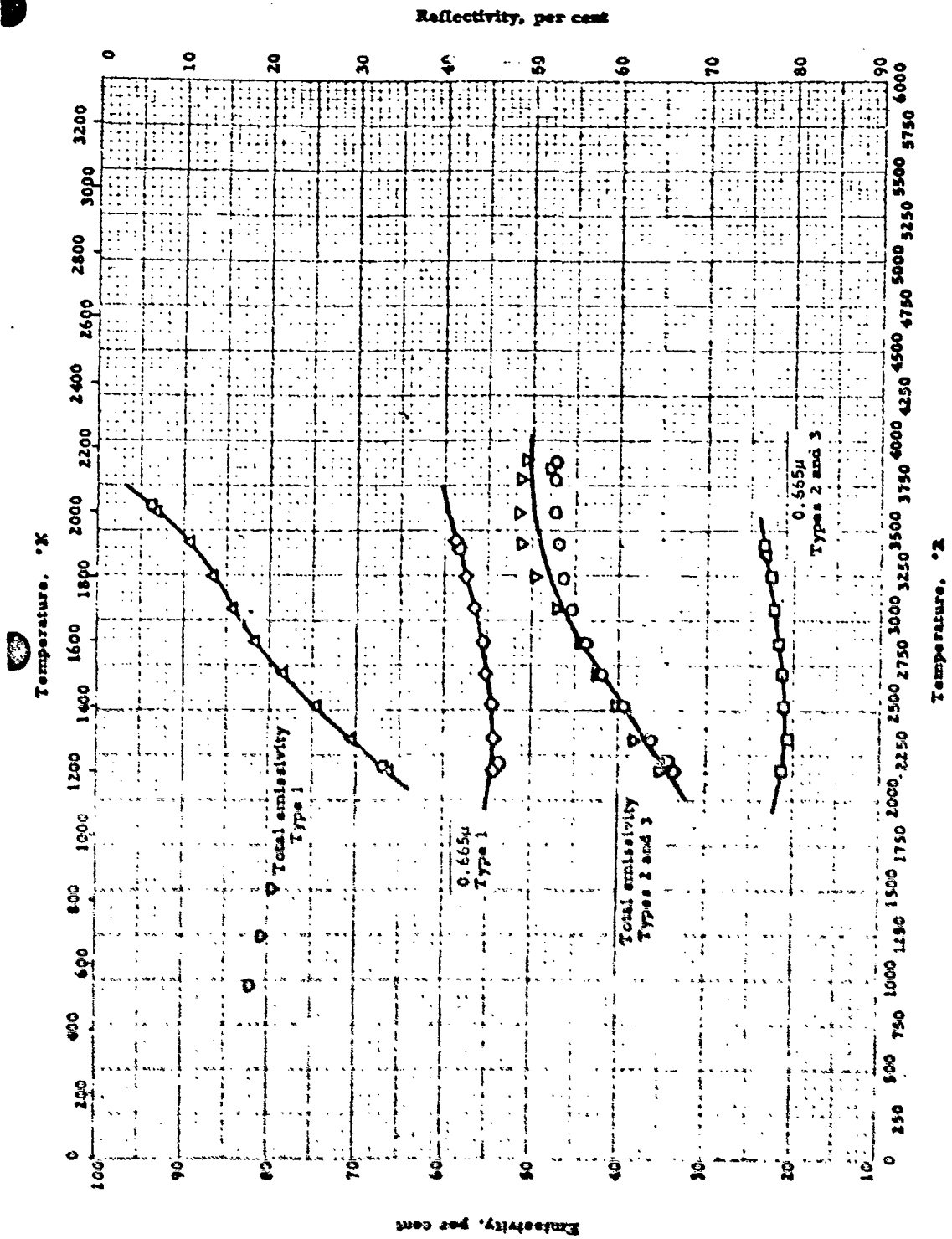


SPECTRAL EMISSIVITY -- BERYLLIUM OXIDE

SPECTRAL EMISSIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
0	Beta, H. T., Clison, O. H., et al.	57-8	Room	Refractory. (Bureau of Standards)	Spectral reflectivity at 9°; sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	Surface as received



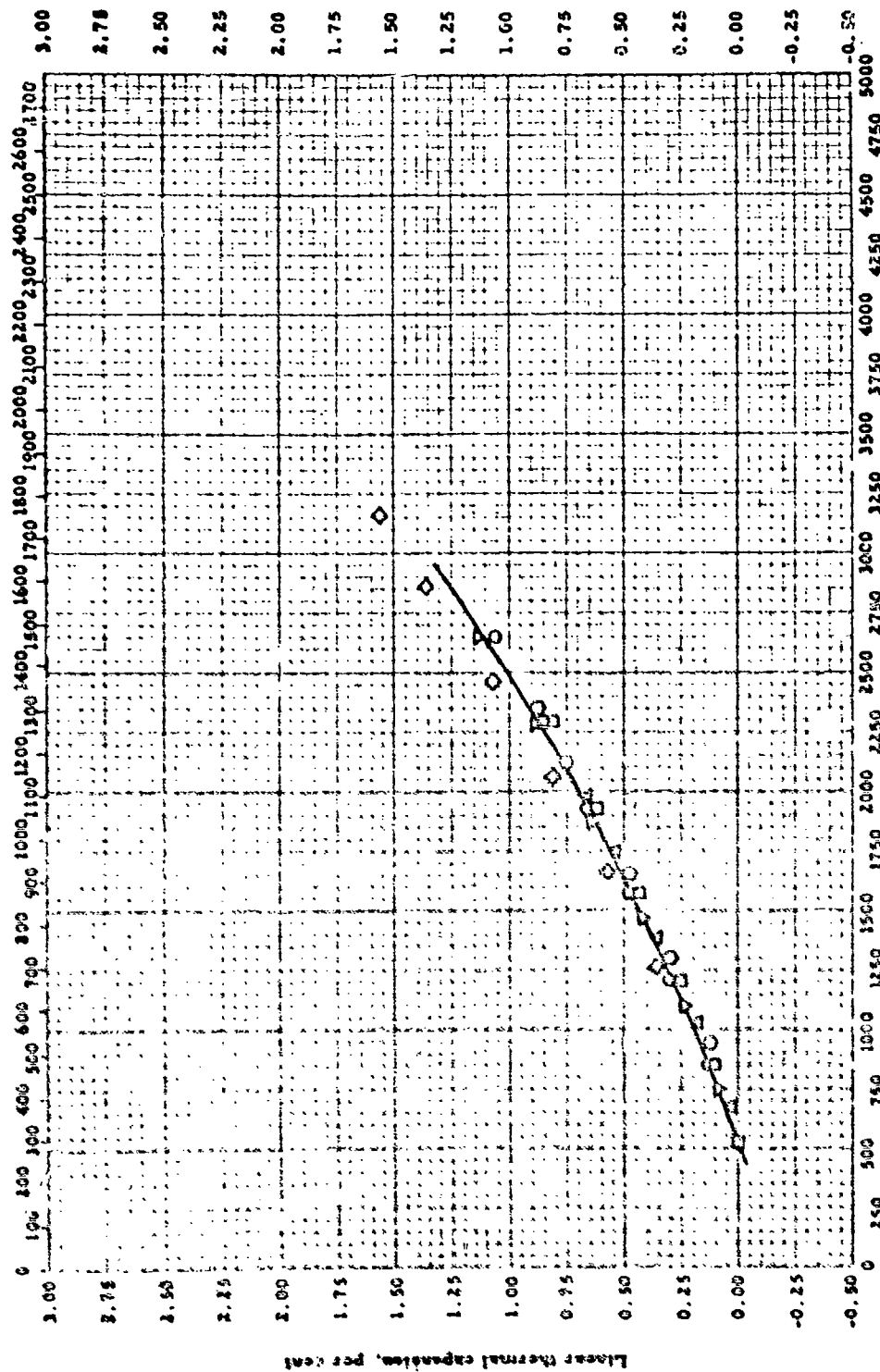
EMISSIVITY -- BERYLLIUM OXIDE

EMISSIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
48-15	Seiders, R. L.	2160-2870	Not given. Type 2 BeO, white, $\rho = 179 \text{ lb}_m/\text{ft}^3$	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated optical pyrometer	Auth. est. $\pm 20\%$ accuracy. Hot pressed powder, annealed, polished, heated to 1300°C in air
48-15	Did.	2160-2870	Same as above	Spectral normal emissivity at 0.66 μ ; comparative; surface brightness compared with a standard, platinum, also auxiliary standards of gold and polished sulfide	Auth. est. $\pm 10\%$ accuracy. Hot pressed powder, annealed, polished, heated to 1300°C in air. Auth. reports same values for Type 2
48-15	Did.	2160-2870	Not given. Type 1 BeO, black, $\rho = 178 \text{ lb}_m/\text{ft}^3$	Same as above	Auth. est. $\pm 10\%$ accuracy. Hot pressed in graphite mold, heated to 1300°C in air
48-15	Did.	2160-2870	Same as above	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated optical pyrometer	Auth. est. $\pm 20\%$ accuracy. Hot pressed in graphite mold, heated to 1300°C in air
48-15	Did.	2160-2870	Not given. Type 2 BeO, white, $\rho = 177 \text{ lb}_m/\text{ft}^3$	Same as above	Auth. est. $\pm 20\%$ accuracy. Hot pressed powder, heated to 1300°C in air
47-23	Argonne National Laboratory	2160-2870	BeO	Spectral normal emissivity; not given	Blackened samples direct from mold. Measured by R. L. Seifert
47-23	Did.	2870	Same as above	Same as above	Same as above, but sample whitened by anneal in air
47-23	Did.	2160-2870	Same as above	Total normal emissivity; total radiation pyrometer	Same as above, but blackened
47-23	Did.	2160-2870	Same as above	Same as above	Same as above, but whitened
99-1	Olson, O. H. and Morris, J. C.	975-1500	BeO	Total normal emissivity; not given	Meas. in air

Temperature, °K



Temperature, °K

LINEAR THERMAL EXPANSION - BERYLLIUM OXIDE

59-257

WADC TR 58-476

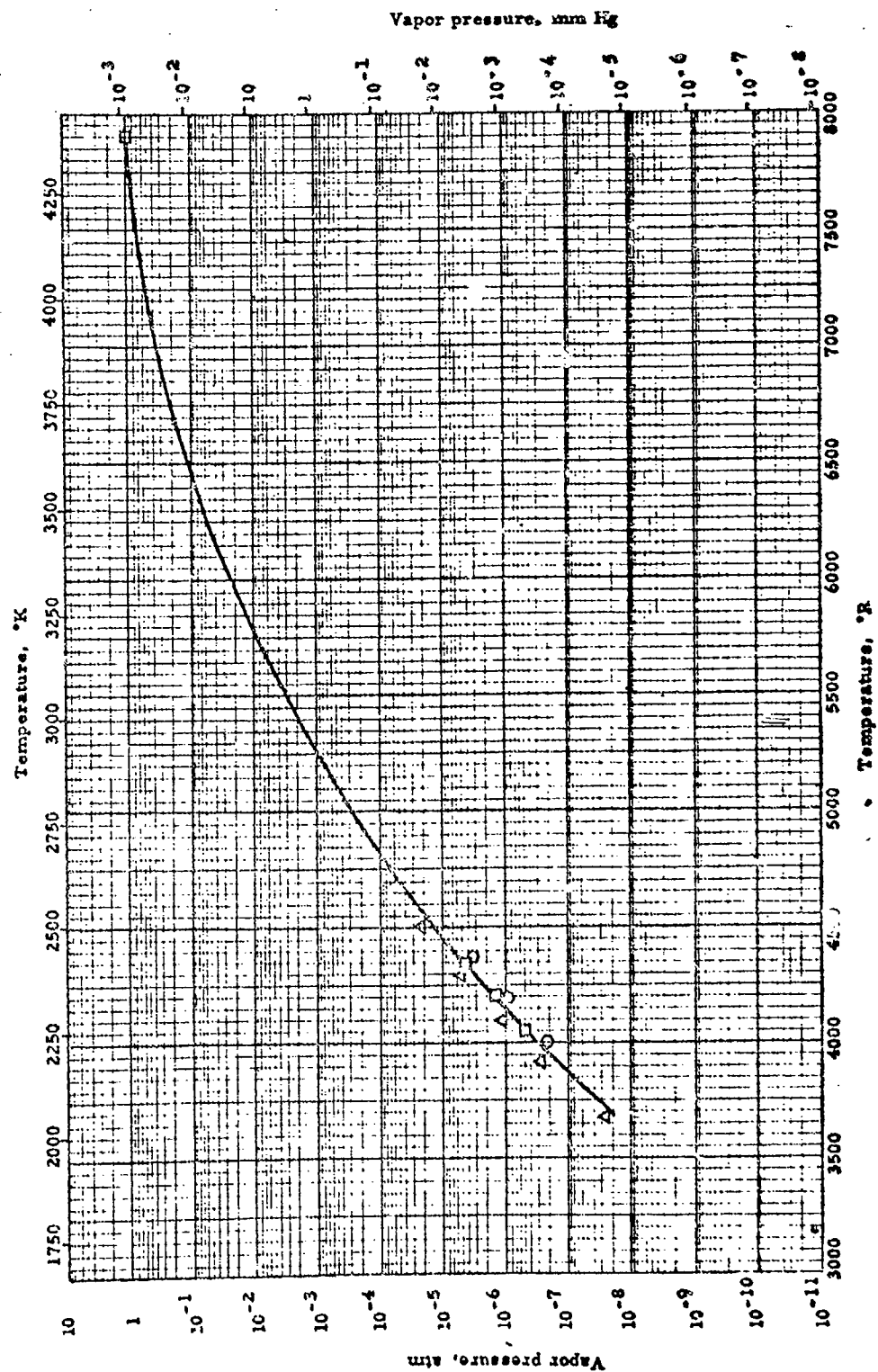
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LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Beale, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade	X-ray back reflection	Ballmilled to 50% < 3 microns, fired at 1820°C
□	Schwartz, Bernard	52-30	852-2292	BeO: apparent porosity = 4%	Quartz tube dilatometer	Same results for 4 samples. 2 dust pressed, 2 extruded, fired at 2800°F and at 3100°F
△	Nelson, H. R.	57-198	530-1932	BeO. Refractory grade. $\rho = 130-139 \text{ lb}_m/\text{ft}^3$	Not given, tested at 100°C/hr. rise	Tested at 305°F/min rise in vacuum of $10^{-6}-10^{-7} \text{ mm Hg}$
◇	Seibel, R. D. and Mason, G. L.	57-154	1260-3162	BeO	Alumina tube differential dilatometer	Hot pressed. Meas. perpendicular to direction of pressing
▽	Fulkerson, E. D.	57-159	490-2650	BeO	Sapphire dilatometer	Plotted avg. of 2 samples. Powder at 1600-2100°C pressed to 1000-2000 psi from Brush S. P. powder
○	Maim, J. G. and Gilbreath, J. R.	48-36	672-2292	BeO $\rho = 170-175 \text{ lb}_m/\text{ft}^3$	Fused quartz dilatometer with dial gauge. Temp. by thermocouple	



60-647
WADC TR 58-476 79

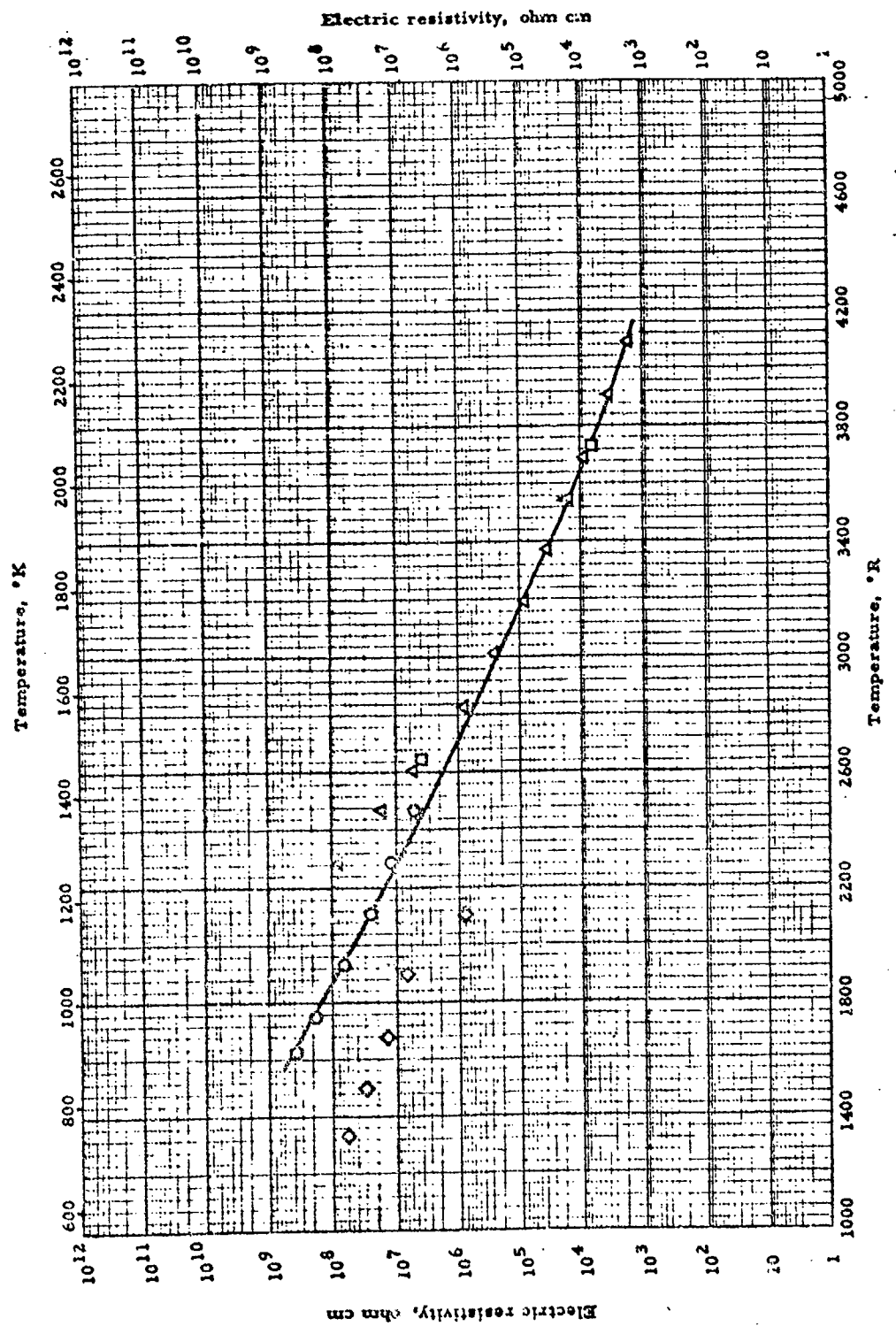
VII - A - 2 -

VAPOR PRESSURE -- BERYLLIUM OXIDE

VAPOR PRESSURE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Argonne National Laboratories	47-23	4002-4362	BeO	Knudsen cell with radio- active counting of ^4Be tracer	Measured by N. D. Erway and R. L. Seifert. Calc. from auth. eq.: $\log_{10} P(\text{mm Hg}) =$ $18.32 - \frac{34,230}{T(^{\circ}\text{K})} - 2 \log_{10} T(^{\circ}\text{K})$
□	Erway, N. D. and Seifert, R. L.	51-82	4050-4181	BeO, 99.2% pure crystals	Knudsen cell with radio- active counting of ^4Be contained in original material. Temperature by optical pyrometer sighting on black body hole	Calc. from auth. eq.: $\log_{10} P(\text{mm Hg}) = 18.50 + 0.23 - \frac{34,230}{T(^{\circ}\text{K})} - 2 \log_{10} T(^{\circ}\text{K})$ from 1977 - 2140° C
△	Yosim, S. J. and Milne, T. A.	57-1-5	3674-4500	BeO	Knudsen effusion cell of Tungsten	Vapor pressure for reaction $2\text{BeO} \rightarrow 2\text{Be} + \text{O}_2$



60-553
WADC TR 58-476 81

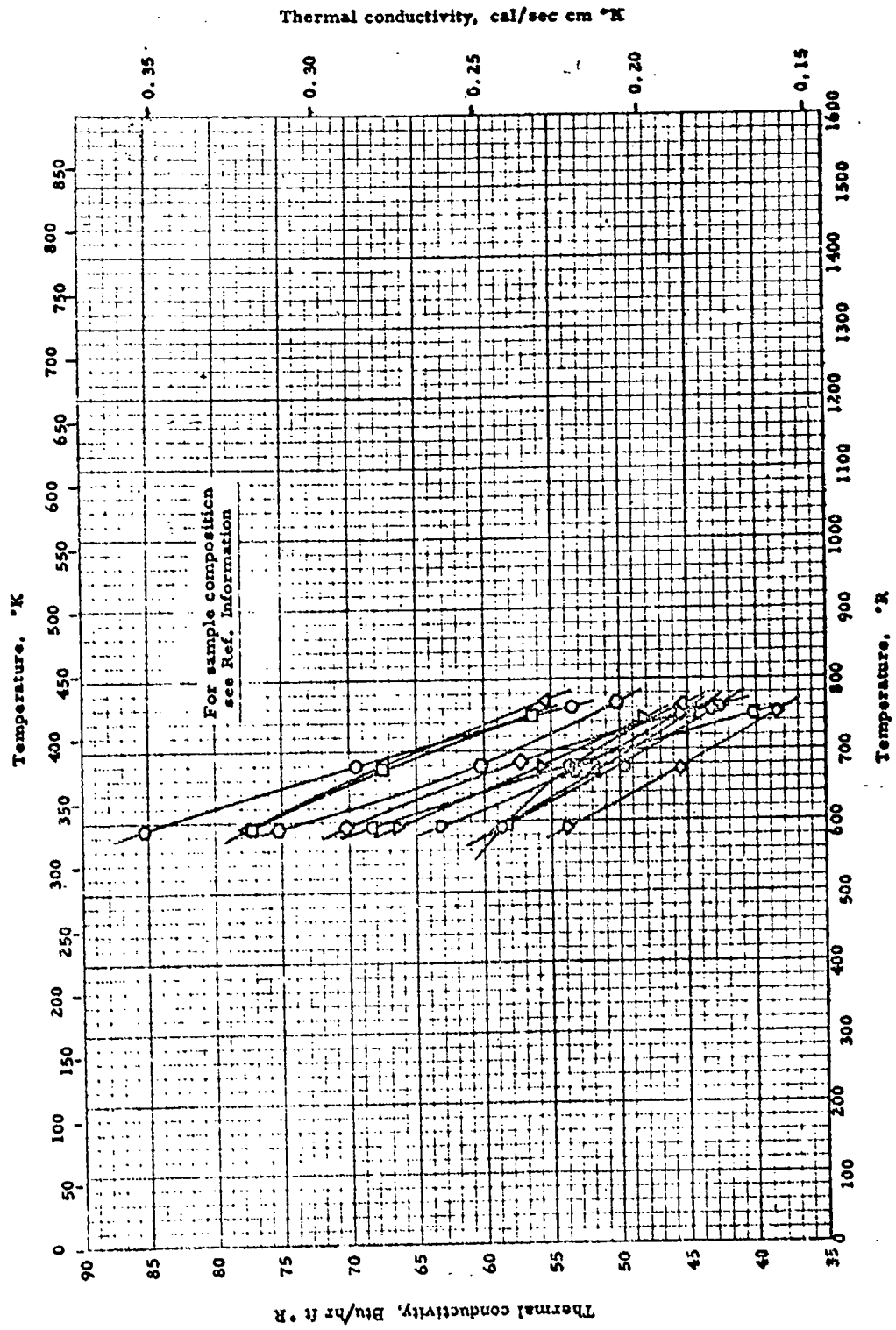
ELECTRIC RESISTIVITY -- BERYLLIUM OXIDE

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ELECTRIC RESISTIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
40-20	Rogener, H.	40-20	1626-2472	BeO	Potential drop. Sample temp. by Pt-Pt Rh thermocouple. Voltage by electrometer.	1 cm cube samples, planitized surfaces. Auth. est. accuracy order of magnitude only
49-16	Trombe, F.	49-16	2652-3732	BeO	Not given	
42-10	Fox, M.	42-10	1752-4272	"Pure" BeO, Glucina. $\rho = 140 \text{ lb}_m/\text{ft}^3$	Potential drop. Sample temp. by optical pyrometer	Optical pyrometer has precision of $\pm 7^\circ\text{C}$ at 2000°C ; calcined at 2100°C
56-73	Nakhodnova, A. P.	56-73	1330-2100	BeO	Potential drop. Sample temp. by Mo-Ni thermocouple. In range $800-900^\circ\text{C}$, optical pyrometer was also used	Formed from chemically pure materials. Baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace. Meas. under 10^{-5} mm Hg, const. current

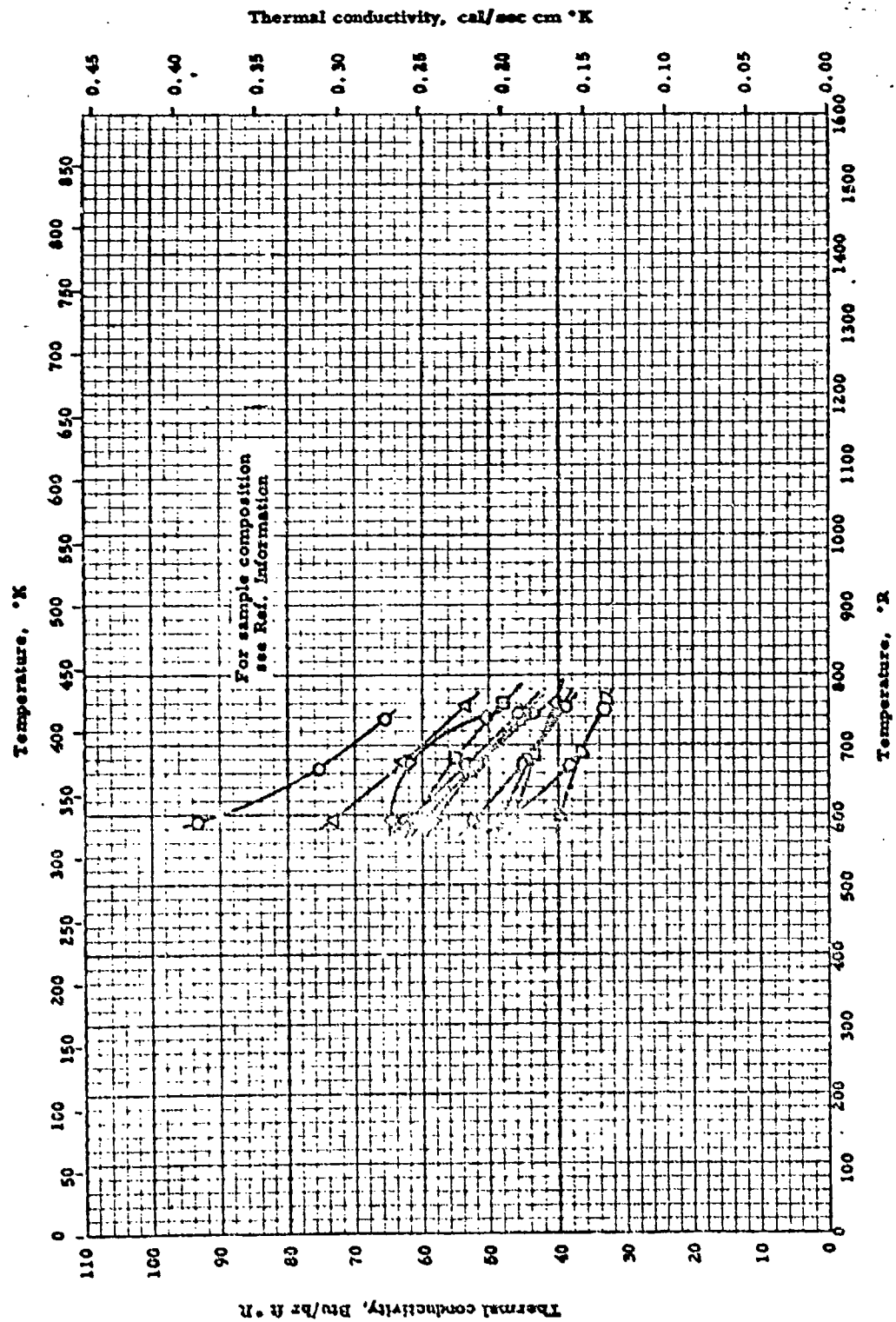


THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + THORIA + MAGNESIA

THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + THORIA + MAGNESIA

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O. Schaefer, W	80-4	593-761	95% BeO; 3.5% Al ₂ O ₃ ; 2.5% ThO ₂	Comparative; rods	Samples formed at 10,000 psi and matured at 1600°C. All raw materials passed 325 mesh screen. Crystalline phases of BeO, ThO ₂ , MgO·Al ₂ O ₃ and MgO present
Id.	50-4	594-747	90% BeO; 5% Al ₂ O ₃ ; 5% ThO ₂	Same as above	Same as above
Id.	50-4	596-769	80% BeO; 10% Al ₂ O ₃ ; 10% ThO ₂	Same as above	Same as above
Id.	50-4	594-755	91.3% BeO; 3.9% MgO; 2.4% Al ₂ O ₃ ; 2.4% ThO ₂	Same as above	Same as above
Id.	50-4	592-748	86.5% BeO; 4.8% Al ₂ O ₃ ; 4.8% ThO ₂ ; 3.9% MgO	Same as above	Same as above
Id.	50-4	591-766	76.9% BeO; 9.6% Al ₂ O ₃ ; 9.6% ThO ₂ ; 3.9% MgO	Same as above	Same as above
Id.	50-4	593-753	88% BeO; 7.4% MgO; 2.3% Al ₂ O ₃ ; 2.3% ThO ₂	Same as above	Same as above
Id.	50-4	592-748	83.4% BeO; 7.3% MgO; 4.6% Al ₂ O ₃ ; 4.6% ThO ₂	Same as above	Same as above
Id.	50-4	594-759	74% BeO; 9.3% Al ₂ O ₃ ; 9.3% ThO ₂ ; 7.4% MgO	Same as above	Same as above
Id.	50-4	596-766	82.6% BeO; 13% MgO; 2.2% Al ₂ O ₃ ; 2.2% ThO ₂	Same as above	Same as above
Id.	50-4	490-746	78.2% BeO; 13% MgO; 4.4% Al ₂ O ₃ ; 4.4% ThO ₂	Same as above	Same as above
Id.	50-4	591-752	69.6% BeO; 8.7% Al ₂ O ₃ ; 8.7% ThO ₂ ; 13% MgO	Same as above	Same as above

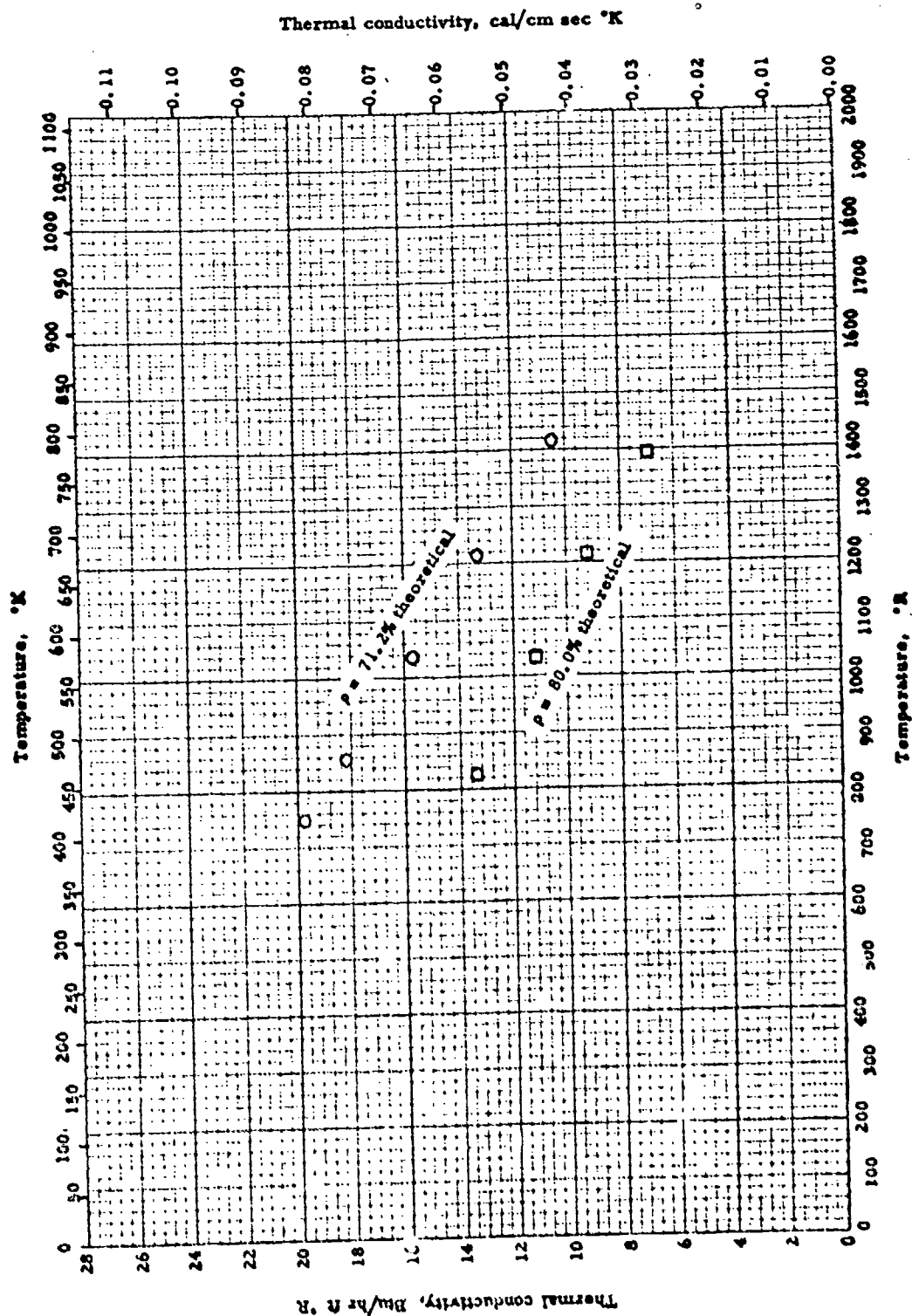


THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + ZIRCONIA + MAGNESIA

THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + ZIRCONIA + MAGNESIA

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
◻ Scholes, W.A.	50-4	589-733	95% BeO; 2.5% Al ₂ O ₃ ; 2.8% ZrO ₂	Comparative; rods	Samples formed at 10 mm psi, and matured at 1600°C. - rials passed 325 mesh screen. Crystalline phases of BeO, ZrO ₂ , BeO·Al ₂ O ₃ and MgO present
◻ Ibid.	50-4	595-758	90% BeO; 5% Al ₂ O ₃ ; 5% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	593-754	80% BeO; 10% Al ₂ O ₃ ; 10% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	590-733	91.3% BeO; 3.9% MgO; 2.4% Al ₂ O ₃ ; 2.4% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	591-745	86.5% BeO; 4.8% Al ₂ O ₃ ; 4.8% ZrO ₂ ; 3.9% MgO	Same as above	Same as above
◻ Ibid.	50-4	591-751	76.9% BeO; 9.6% Al ₂ O ₃ ; 9.6% ZrO ₂ ; 3.9% MgO	Same as above	Same as above
◻ Ibid.	50-4	591-745	88% BeO; 7.4% MgO; 2.3% Al ₂ O ₃ ; 2.3% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	593-746	83.4% BeO; 7.4% MgO; 4.6% Al ₂ O ₃ ; 4.6% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	595-758	74% BeO; 9.3% Al ₂ O ₃ ; 9.3% ZrO ₂ ; 7.4% MgO	Same as above	Same as above
◻ Ibid.	50-4	599-758	78% BeO; 6% ZrO ₂ ; 7.4% MgO; 6.6% Al ₂ O ₃	Same as above	Same as above
◻ Ibid.	50-4	686-736	82.6% BeO; 13% MgO; 2.2% Al ₂ O ₃ ; 2.2% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	592-747	78.2% BeO; 13.0% MgO; 4.4% Al ₂ O ₃ ; 4.4% ZrO ₂	Same as above	Same as above
◻ Ibid.	50-4	597-764	69.6% BeO; 13% MgO; 8.7% Al ₂ O ₃ ; 8.7% ZrO ₂	Same as above	Same as above



THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM OXIDE

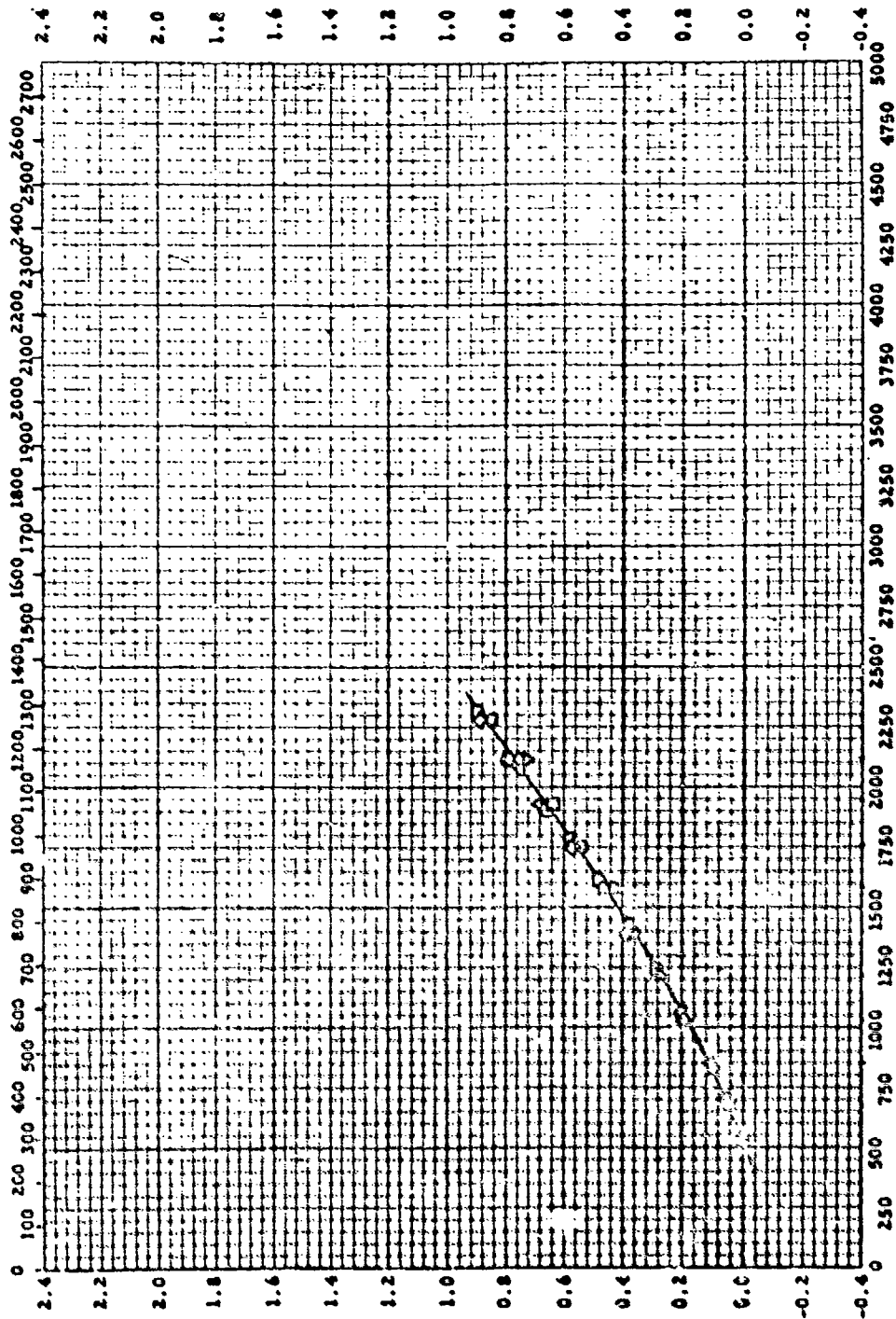
THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Two methods:

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Mc Creight, L. R.	57-148	744-1410	53% BeO; 47% UO ₂ . ρ = 71.2% theoretical	Two methods: a) comparative, rods and b) axial heat flow in rod, calorimeter sink guarded sample	Sintered
□	Ibid.	57-148	825-1392	23% BeO; 47% UO ₂ . ρ = 80.0% theoretical	Same as above.	Sintered

Temperature, °K



Linear thermal expansion, per cent

Temperature, °K

LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + X

59-222

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LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + X

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
46-4	Geller, R. F., Yavarsky, P. J. et al.	528-2292	89.55% BeO; 9.91% ThO ₂ ; 4.56% Al ₂ O ₃ ; prepared from 99.7% pure BeO, 99+% pure Al ₂ O ₃ , 99+% pure ThO ₂ (calcined)	Interferometer	(16BeO · 3Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	76.63% BeO; 16.86% ThO ₂ ; 6.5% Al ₂ O ₃ ; raw materials same as above	Same as above	(48 BeO · Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	64.11% BeO; 21.78% Al ₂ O ₃ ; 14.11% ThO ₂ ; raw materials same as above	Same as above	(48BeO · 4Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	56.19% BeO; 24.72% ThO ₂ ; 19.09% Al ₂ O ₃ ; raw materials same as above	Same as above	(24BeO · 2Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	48.33% BeO; 31.04% Al ₂ O ₃ ; 10.63% ThO ₂ ; raw materials same as above	Same as above	(48BeO · 10Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	45.05% BeO; 39.65% ThO ₂ ; 15.30% Al ₂ O ₃ ; raw materials same as above	Same as above	(12BeO · Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	40.12% BeO; 39.34% Al ₂ O ₃ ; 23.54% ThO ₂ ; raw materials same as above	Same as above	(18BeO · 4Al ₂ O ₃ · ThO ₂)
46-4	Ibid.	528-2292	40.12% BeO; 6.05% MgO; 3.83% Al ₂ O ₃ ; prepared from 97% pure MgO, 99.7% pure BeO, 99+% pure Al ₂ O ₃	Same as above	(4MgO · 96BeO · Al ₂ O ₃)
46-4	Ibid.	528-2292	73.77% BeO; 18.80% Al ₂ O ₃ ; 7.43% MgO; raw materials same as above	Same as above	(MgO · 16BeO · Al ₂ O ₃)

PROPERTIES OF CALCIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	207 lb _m /ft ³ *	3.35 g/cm ³ *
Melting Point.	5120°R	2840°K
Heat of Fusion.		
Heat of Vaporisation. . .		
Heat of Sublimation. . .		

*Handbook Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	187	3.0
□	109	1.74

<u>Melting Point:</u>	°R	°K
Δ	5116	2843

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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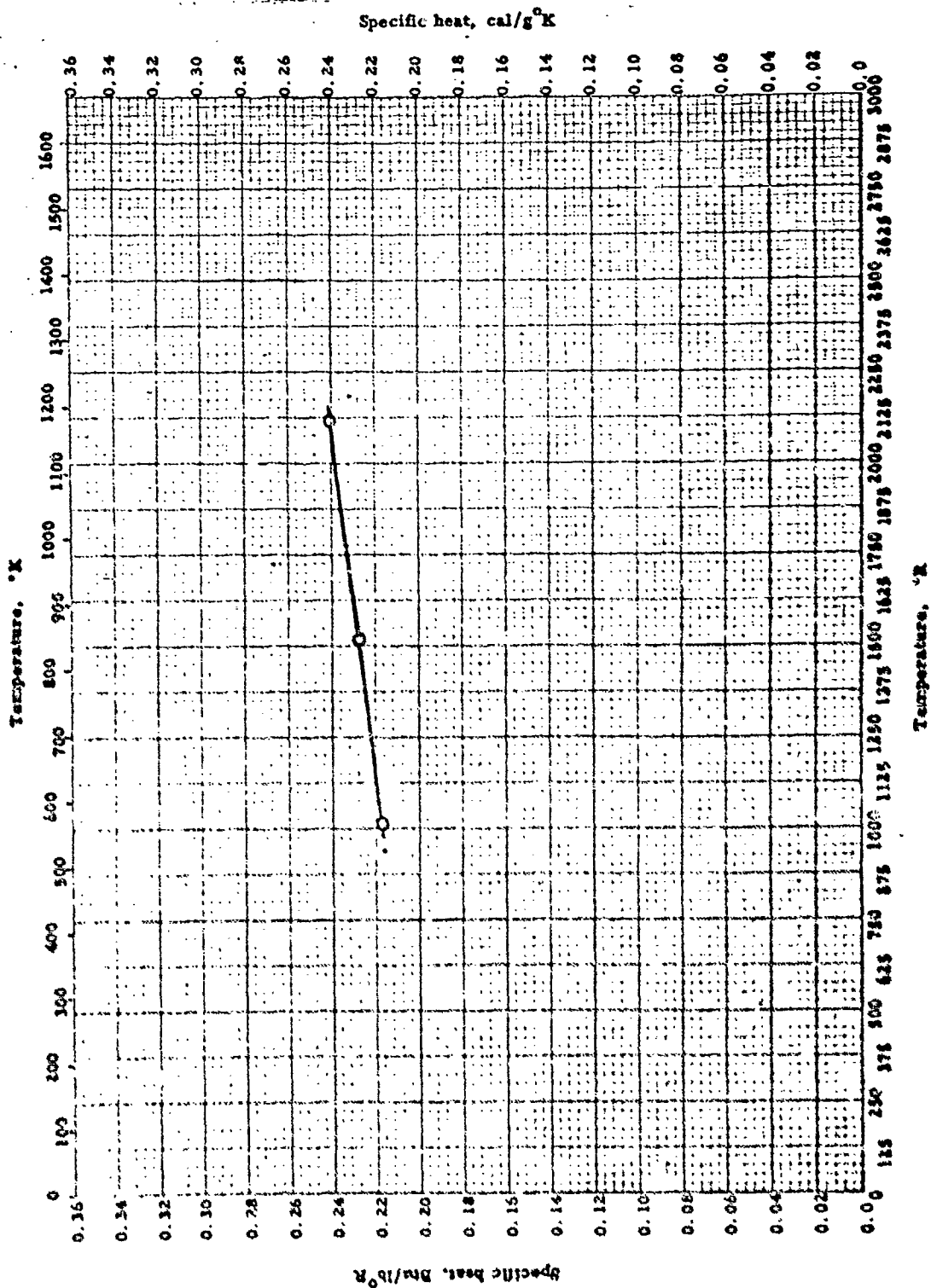
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF CALCIUM OXIDE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Fischer, H. C.	55-67	Room	Not given; made from high-purity calcium carbonate	p: weight and volume by mercury displacement	Dense material; p varies with calcining temp., retention time, heating rate
□	Idid.	55-67	Room	Same as above	p: same as above	Light material; p varies with calcining temp., retention time, heating rate
Δ	Trombe, F.	49-76	518	Not given	MP: not given	



SPECIFIC HEAT -- CALCIUM OXIDE

SPECIFIC HEAT -- CALCIUM OXIDE

REFERENCE INFORMATION

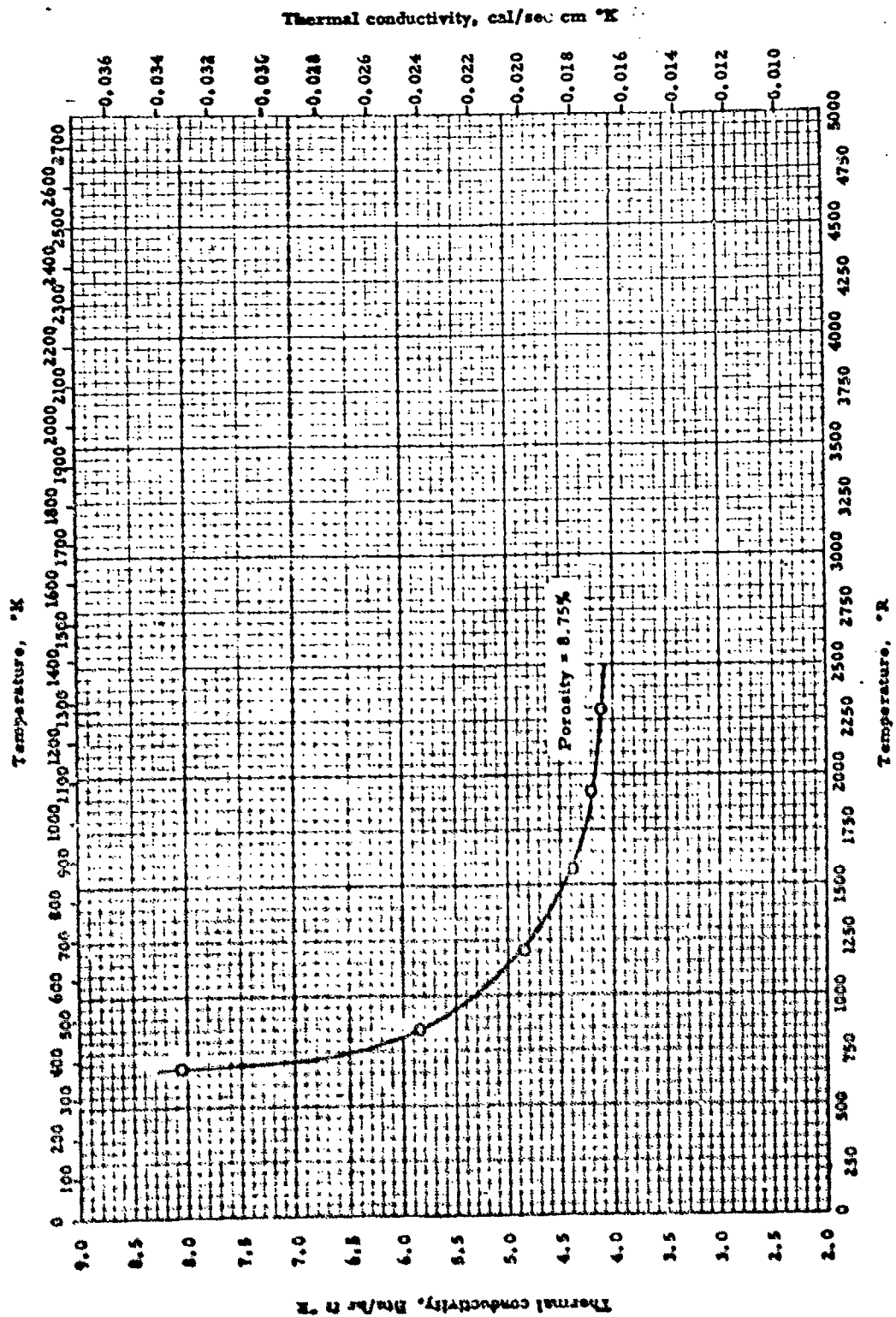
Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
0	Lundar, J. J.	51-78	1010-2120	CaO	Drop method, calibrated by Pt sample.	Material obtained by calcining CaO ₃ at 800°C in vacuum. Computed C from quadratic equation fitted to author's enthalpy values by least-mean squares routine at ARJ.

58-317

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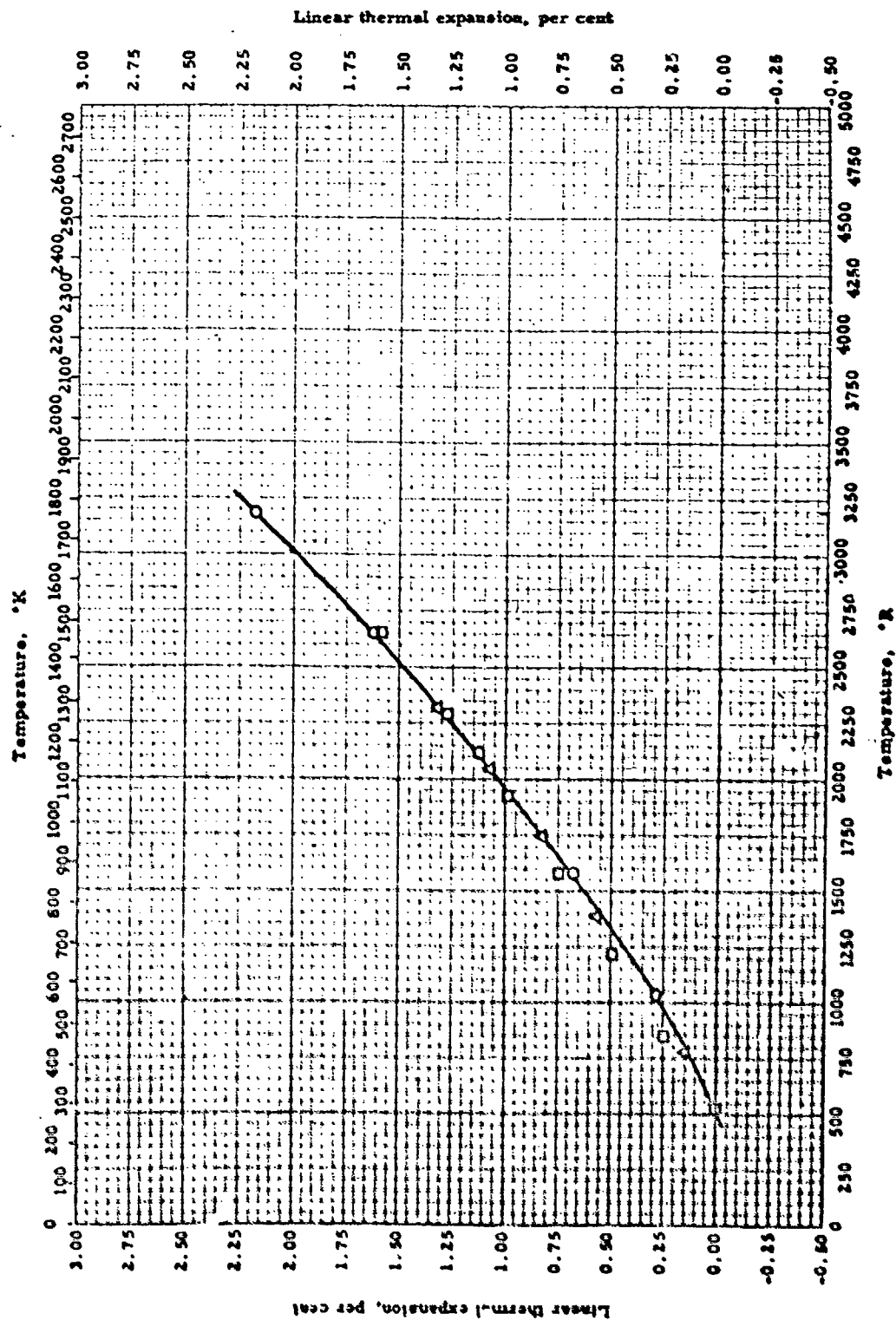


Thermal conductivity - CALCIUM OXIDE

THERMAL CONDUCTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

O	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kingery, W. D., and Franchi, J.	54-1	672-2292	$\rho = 189 \text{ lb}_m/\text{ft}^3$; porosity = 8.75%	Comparative; rods	Prepared by calcining c. p. CaCO_3 at 1600°C and pressing; fired at 1900°C

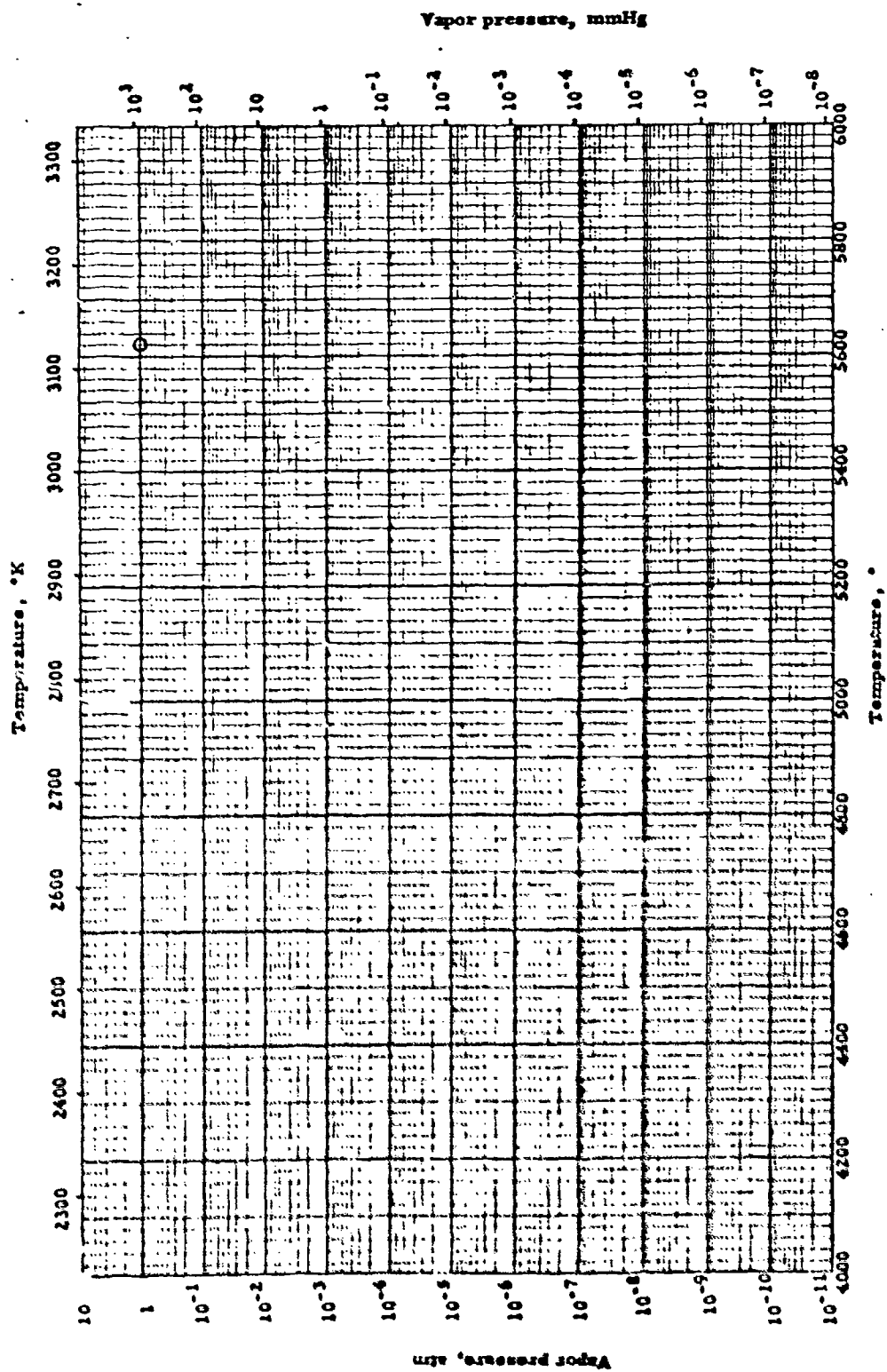


LINEAR THERMAL EXPANSION - CALCIUM OXIDE

LINEAR THERMAL EXPANSION -- CALCIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Coarse fused grain CaO	Telemicroscopes sight- ing on sample	
□	Beale, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade CaO	X-ray back reflection	
△	Eichelberger, R. L.	54-146	492-2300	CaO	Interferometer below 1000°C; Dilatometer above 1000°C	



VAPOR PRESSURE--CALCIUM OXIDE

VAPOR PRESSURE -- CALCIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Tromba, F.	49-16	5622	CaO	Not given	

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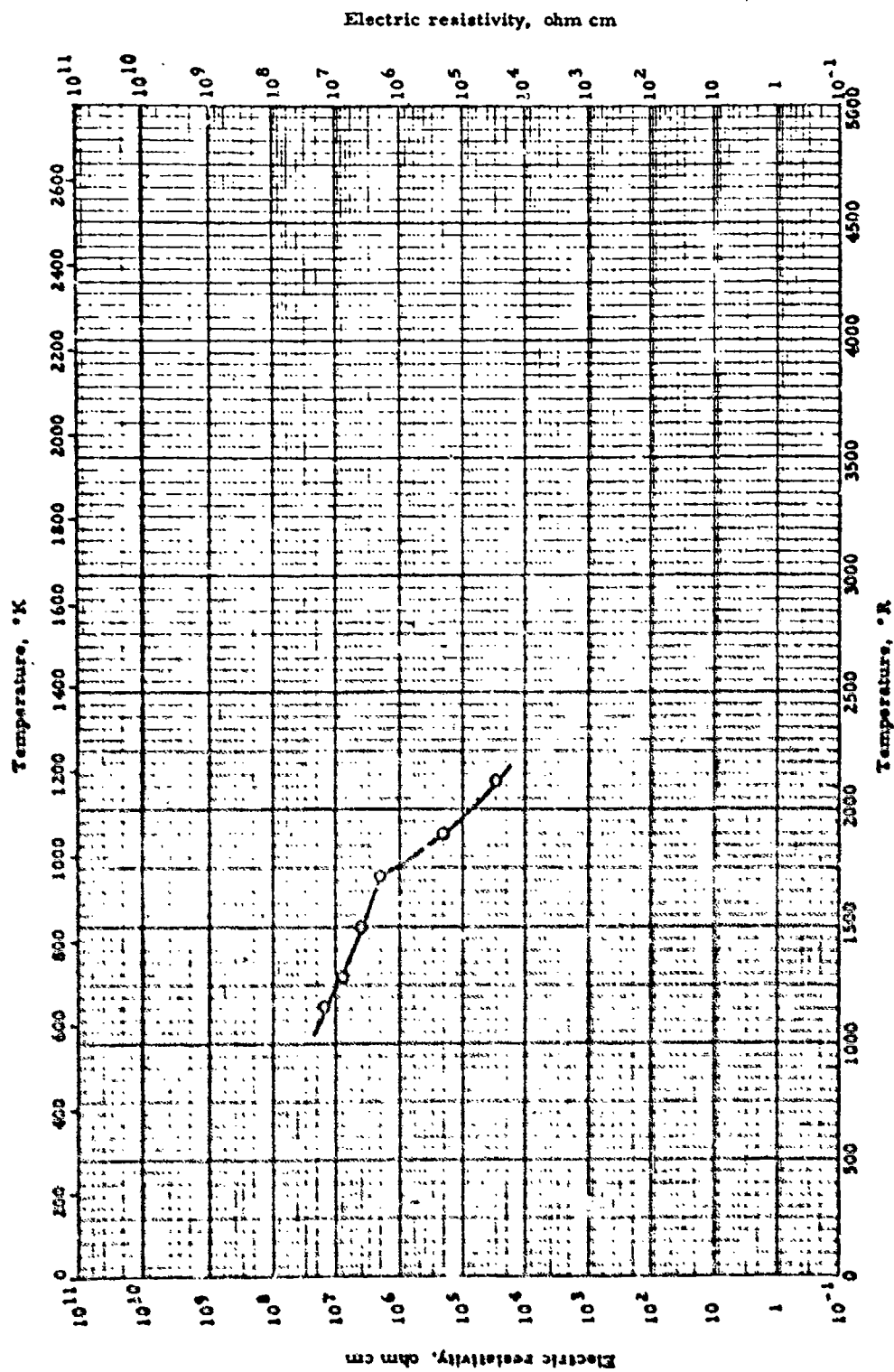
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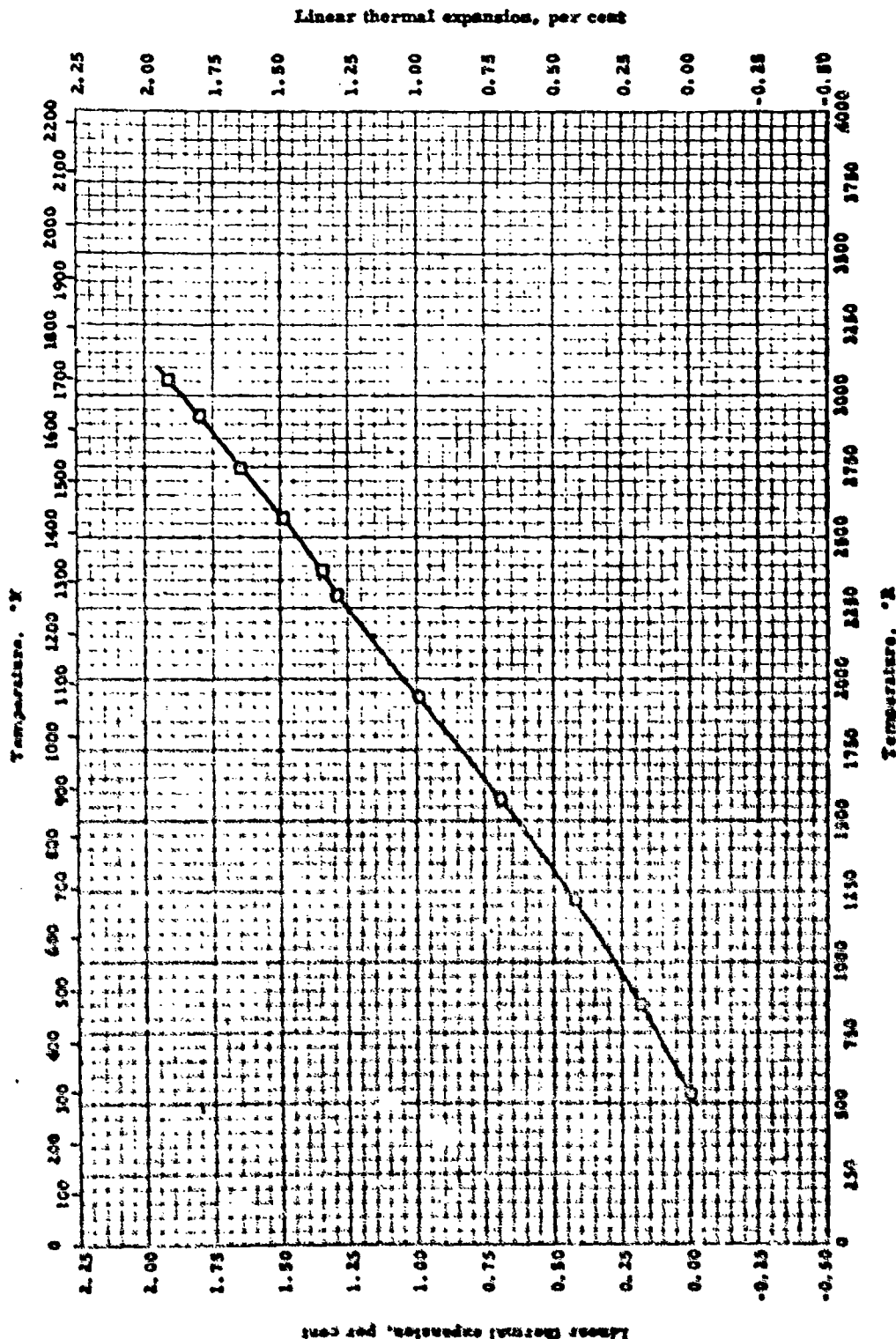


ELECTRIC RESISTIVITY -- CALCIUM OXIDE

ELECTRIC RESISTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

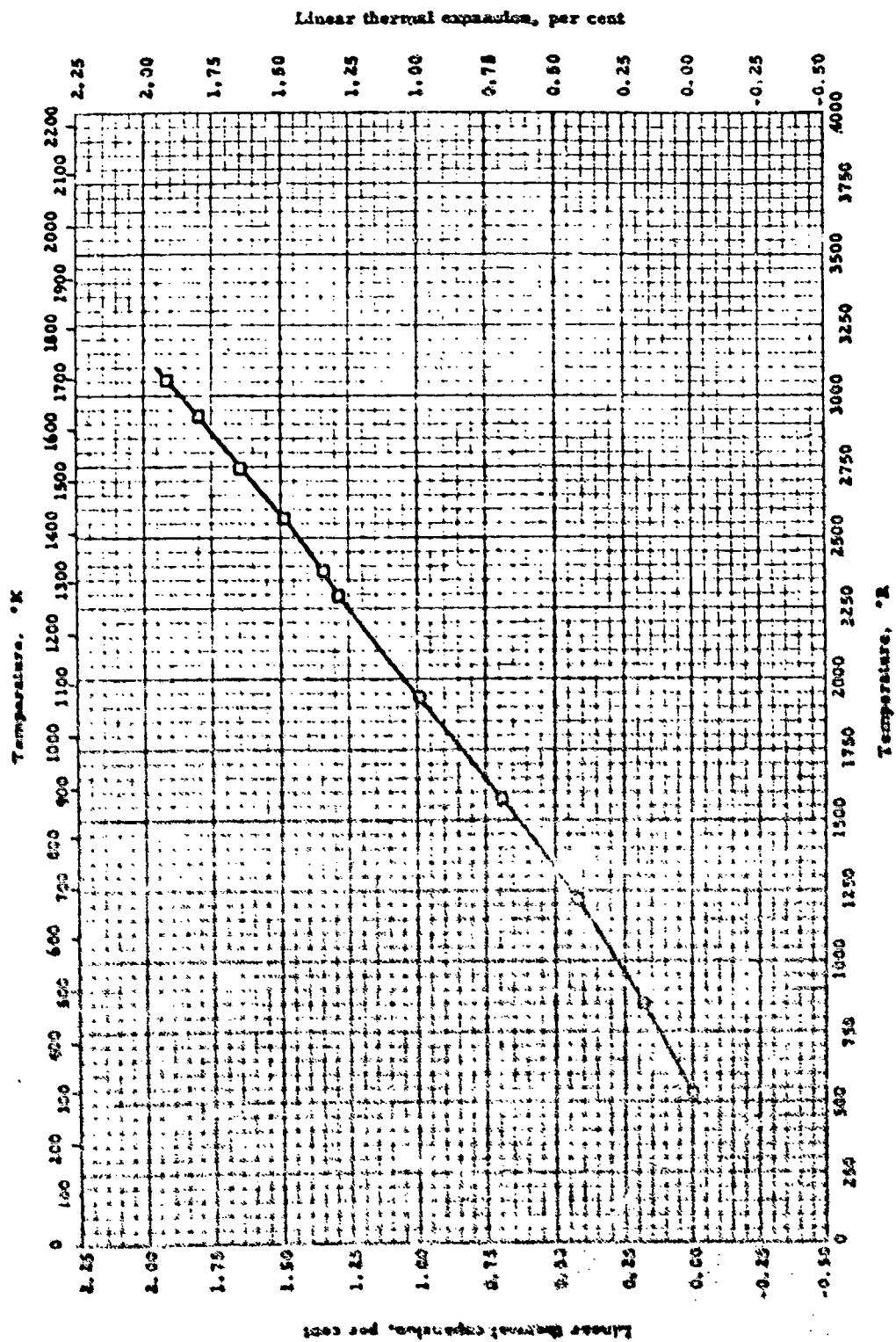
Sym No.	Investigator	Rd.	Range, °R	Material Composition	Test Method	Remarks
0	Nathondanova, A. P.	58-73	1160-1180	CaO; polycrystalline	Potential drop; sample temp. by thermocouple and optical pyrometer	Prepared from chemically pure materials. Calcined 2 hr. at 0.46 of MP



LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE

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LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE

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LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
54-146	Eichelberger, R. L.	672-2272	Stabilized calcia. 94.72% CaO; 5.28% TiO ₂	Two methods: a. below 1000°C: dilatometer b. above 1000°C: dilatometer	Pressed, fired to 1700°C
54-146	Ibid.	2292-3057	Stabilized calcia. 95.57% CaO; 4.43% TiO ₂	Same as above	Same as above

PROPERTIES OF CERIUM OXIDE + URANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, 43.6% UO_2 . . .	525 lb_m/ft^3	8.42 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb_m/ft^3	g/cm^3
○	518	8.30
□	525	8.42
△	501	8.03
◇	443	7.1

<u>Melting Point:</u>	$^{\circ}\text{R}$	$^{\circ}\text{K}$
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<u>Heat of Fusion:</u>	Btu/lb_m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb_m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb_m	cal/g
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PROPERTIES OF CERIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○ Rudorff, W. and Valel, G.	53-85	Room	55.1% CeO ₂ ; 44.9% UO _{2.67}	p: not given	
□ Ibid.	53-85	Room	56.4% CeO ₂ ; 43.6% UO ₂	p: same as above	
△ Ibid.	53-85	Room	71.1% CeO ₂ ; 28.9% UO _{2.67}	p: same as above	
◇ Ibid.	53-85	Room	CeO ₂	p: same as above	

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	443 lb _m /ft ³	7.19 g/cm ³
Melting Point	5530°R	3970°K
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

Density:	lb _m /ft ³	g/cm ³
Q	443	7.10

<u>Melting Point:</u>	°R	°K
□	5534	3273

<u>Heat of Fusion:</u>	<u>Btu/lb_m</u>	<u>cal/g</u>
100	100	100

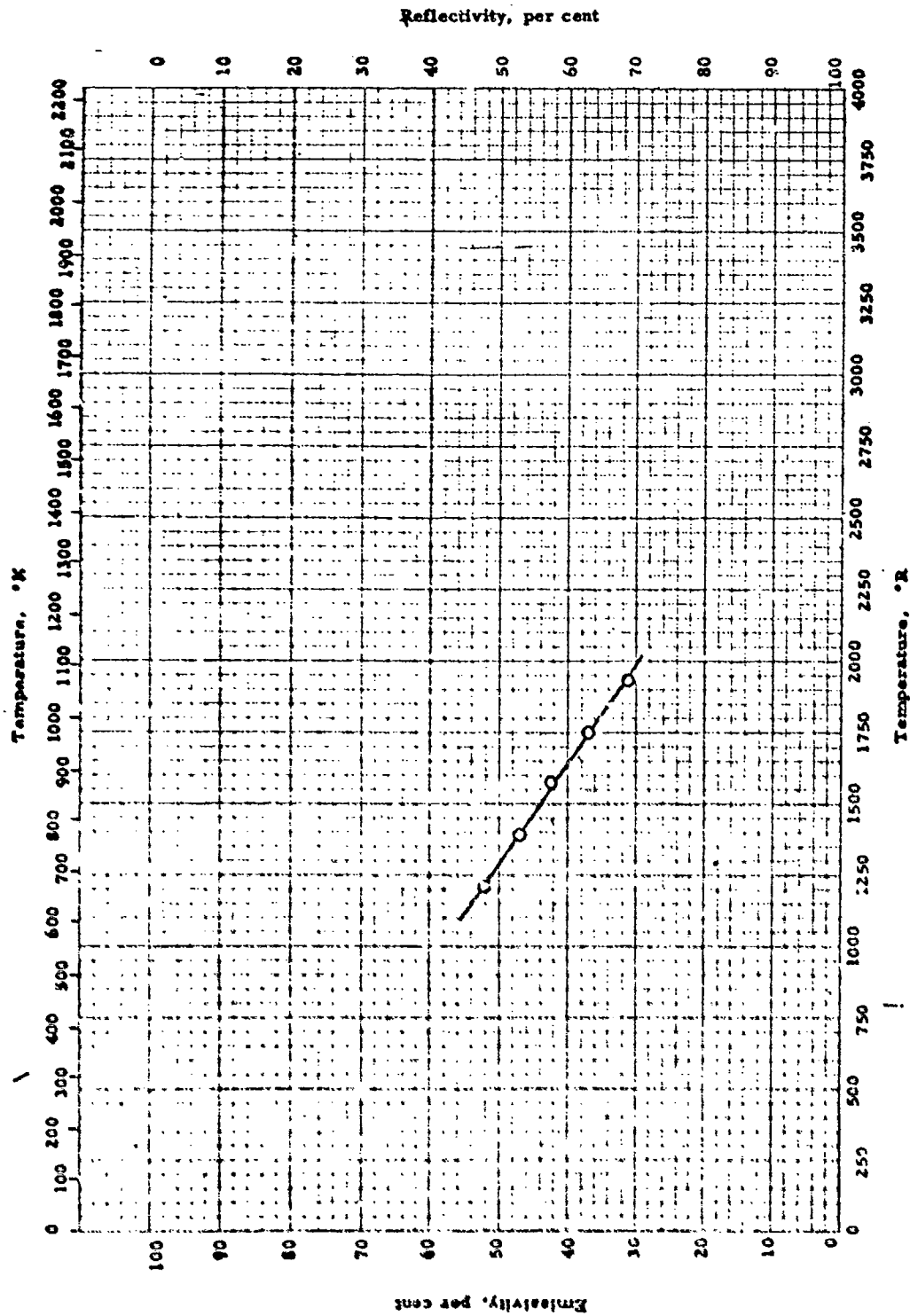
Heat of Vaporization:	Btu/lb _m	cal/g
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Heat of Sublimation:	Btu/lb _m	cal/g
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PROPERTIES OF CERIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
53-85	Rudolf, W., and Valer, G.	Room	Not given	p: not given	
49-16	Troerba, F.	5532	Not given	MP: not given	



EMISSIVITY -- CERIUM OXIDE

9-1095

WADC TR 58-476

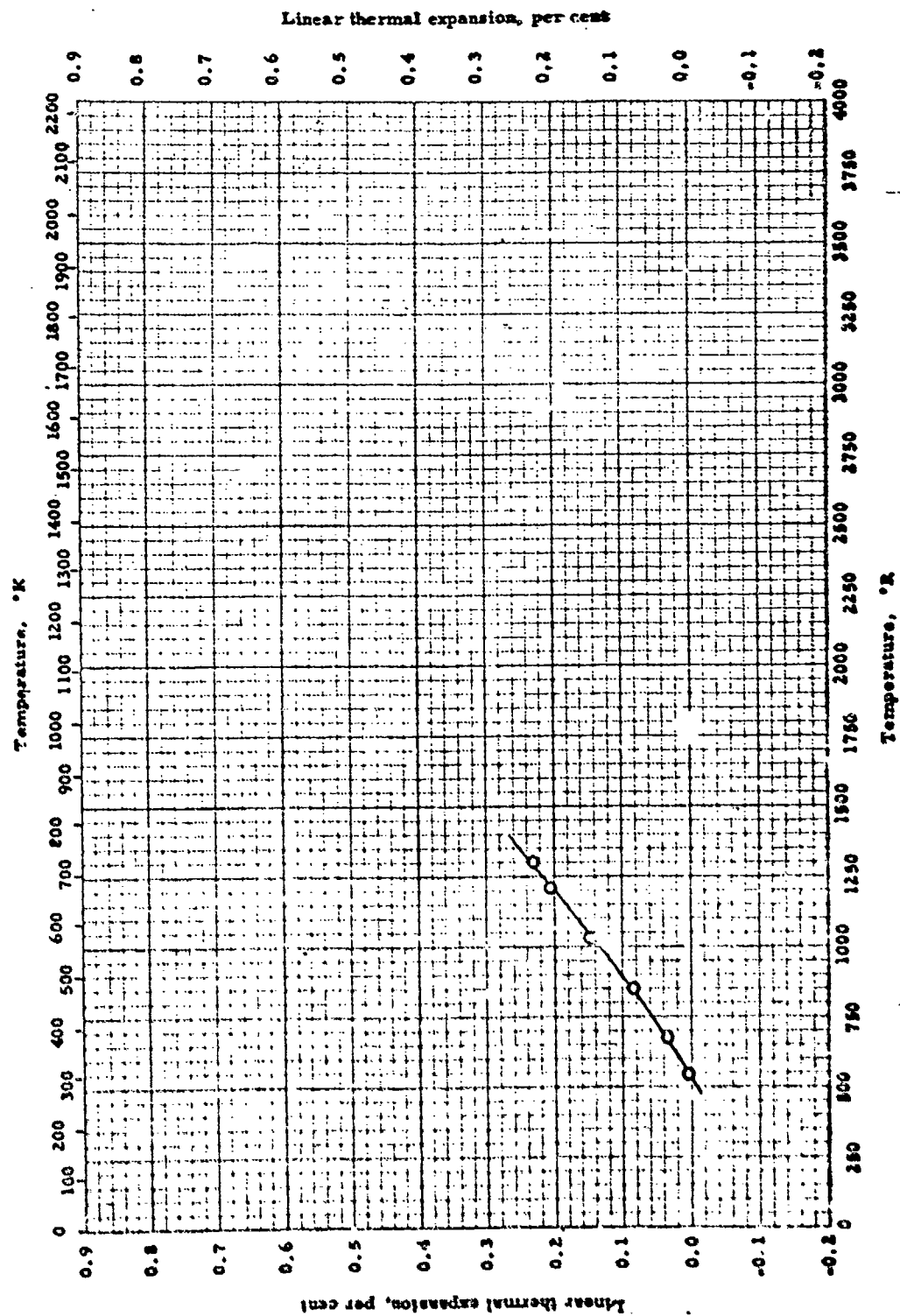
109

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EMISSION -- CERUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Sally, A. H., Briggs, E. A. and Waterhouse, R. B.	52-81	1212-1932	"Pure"	Total normal emissivity; radiant heat meas. with thermopile; sample temp by calibrated Pt-Rh ther- mocouple	



LINEAR THERMAL EXPANSION - $2 \text{ CoO} \cdot \text{V}_2\text{O}_4$

59-287

WADC TR 58-476

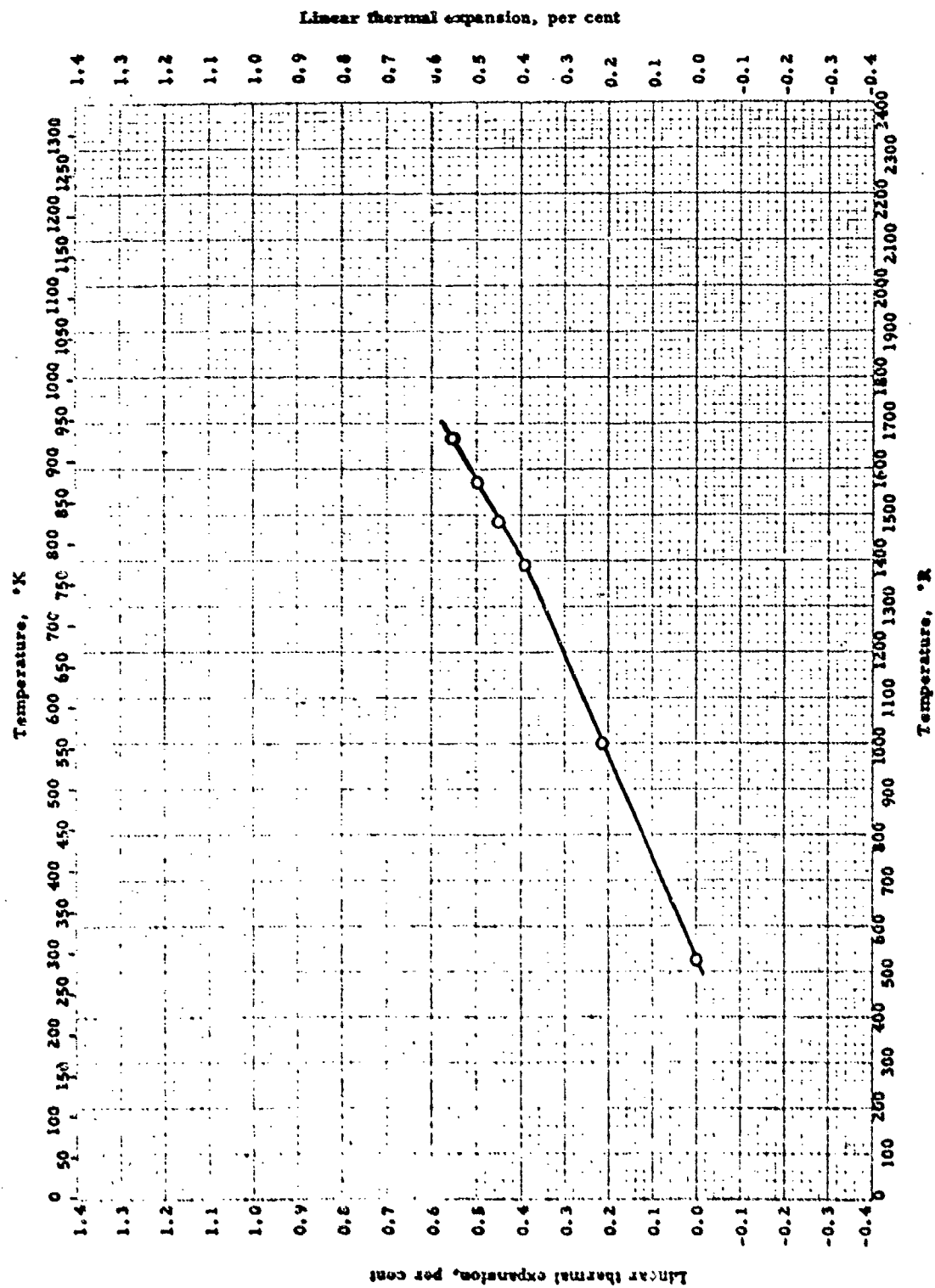
III

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LINEAR THERMAL EXPANSION -- $2\text{CeO}_2 \cdot \text{V}_2\text{O}_4$

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, B. W., and Suber, L. L.	55-17	571-1302	Not given	Vitreous silica tube dilata- tometer	Heated to 1090° - 1200°C



LINEAR THERMAL EXPANSION -- CERIUM OXIDE

LINEAR THERMAL EXPANSION -- CERIUM OXIDE

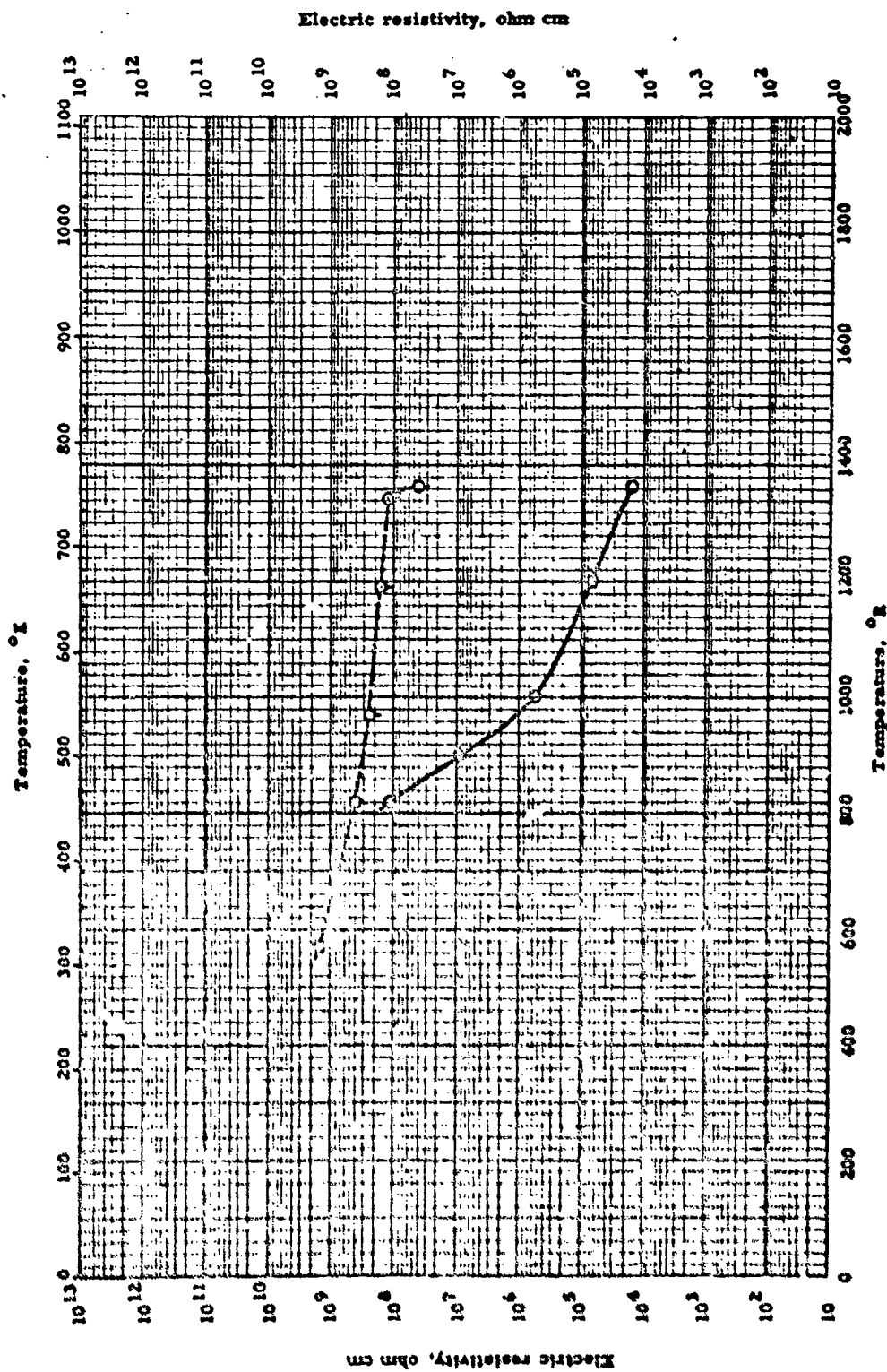
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hummel, F. A. and Henry, E. C.	46-13	528-1662	Cerium oxide, ceria	Fused quartz tube dilatometer	

60-578

WADC TR 55-476

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ELECTRIC RESISTIVITY -- CERUM OXIDE

ELECTRIC RESISTIVITY -- GERMIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Cassidena, A. W. and Hough, J. M.	57-178	570-1164	GeO ₂	Temp. by thermocouples calibrated against secondary standard chromel-alumel thermocouple	Column purified powder, compacted in hand screwed apparatus. Auth. states values are inaccurate. Only interested in shape of curve. Values sensitive to partial pressure of oxygen. O-heating, Q-cooling

PROPERTIES OF DYSPROSIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	482 lb _m /ft ³	7.81 g/cm ³
Melting Point.	4700°R	2610°K
Heat of Fusion.		
Heat of Vaporization. . .		
Heat of Sublimation. . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
	4700 ± 10	2612 ± 10
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF DYSPROSIUM OXIDE

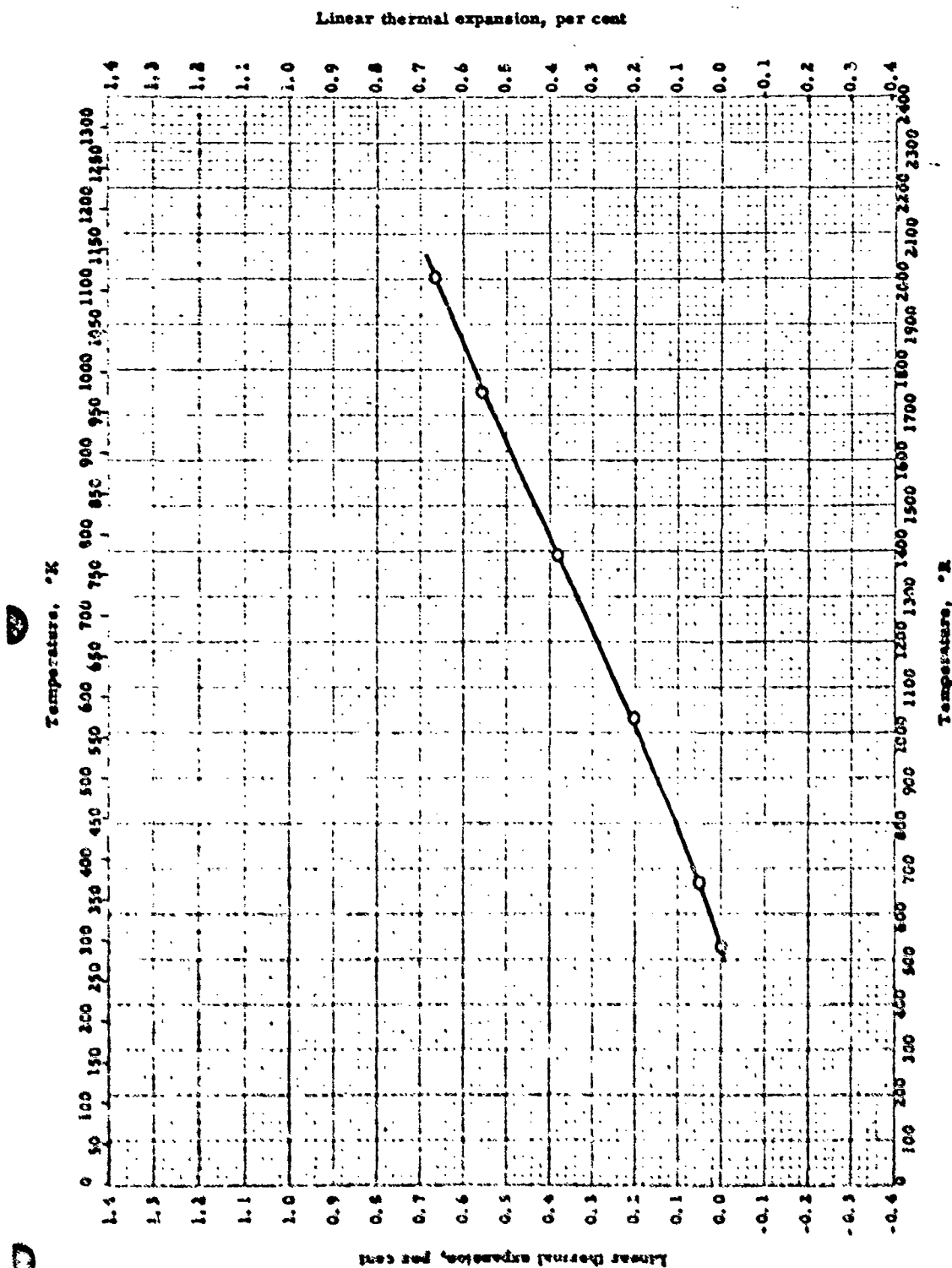
REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bruch, C. A. and Cashin, W. D.	34-109	4686-4722	Dy ₂ O ₃	MP: observation of first liquid drop on V-shaped ribbon, temp. by cali- brate optical pyrometer	

60-685

WADC TM 30-476

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LINEAR THERMAL EXPANSION -- DYSPROSIUM OXIDE

LINEAR THERMAL EXPANSION -- DYSPROSIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Floetz, G. L., Kryszewski, C. W., and Dumes, H. E.	57-189528-2004		Dysprosia, Dy ₂ O ₃	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density

PROPERTIES OF EUROPIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	463 lb _m /ft ³ *	7.42 g/cm ³ *
Melting Point	4180°K	2328°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook of Chemistry and Physics (Ref. 59-2)

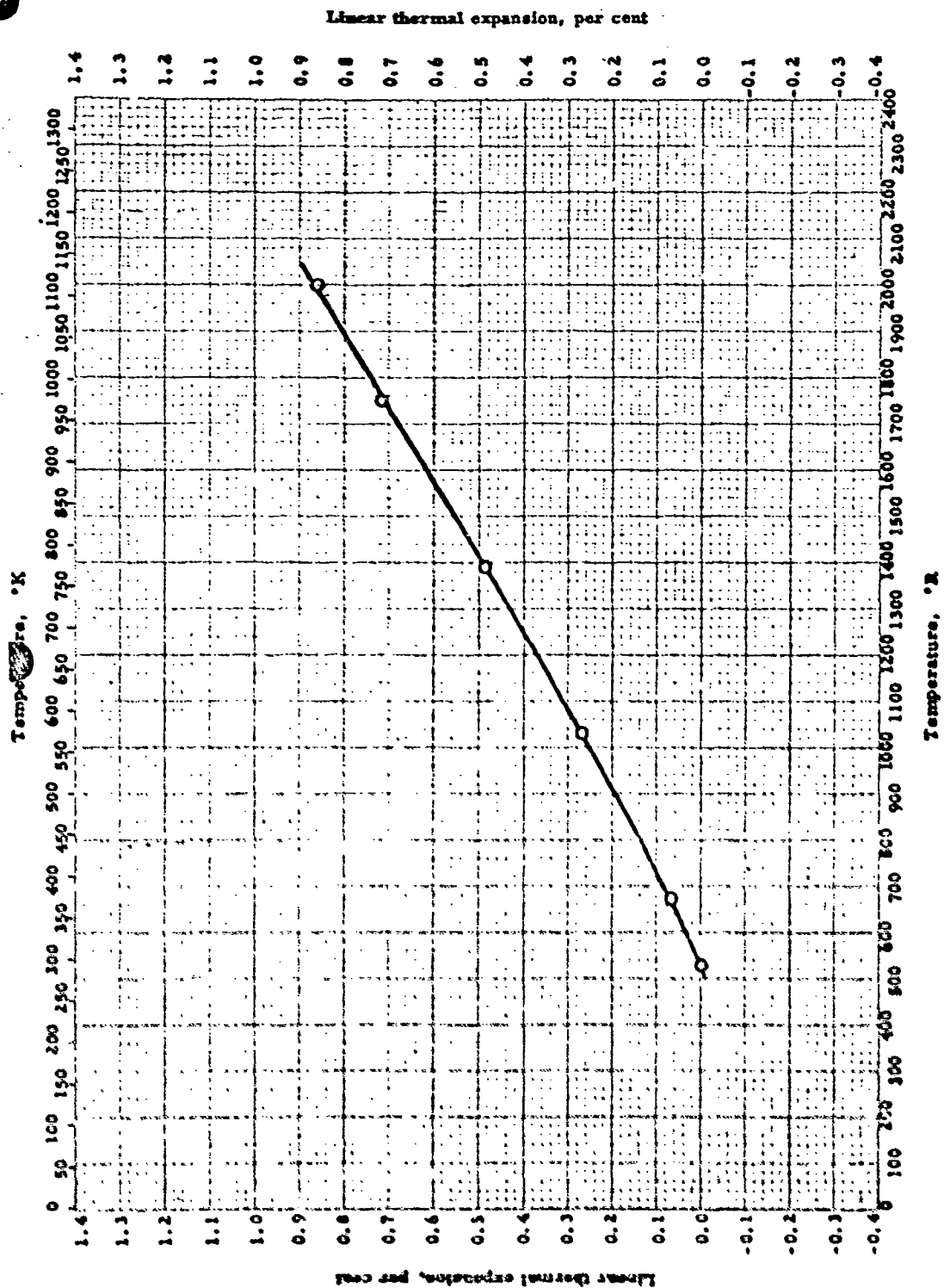
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°K	°K
	4182 ± 54	2323 ± 30
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF EUROPIUM OXIDE

REFERENCE INFORMATION

O	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bruch, C. A. and Cashin, W. M.	56-109	4123-4236	Eu ₂ O ₃	MP: observation of first liquid drop on V-shaped ribbon; temp. by optical pyrometer	



LINEAR THERMAL EXPANSION -- EUROPIUM OXIDE

LINEAR THERMAL EXPANSION -- EUROPIUM OXIDE

REFERENCE INFORMATION

Sym Enl	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Floetz, G. L., Kryszewski, C. W. and Dams, R. E.	57-189	528-2004	Europia. Eu_2O_3	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density

PROPERTIES OF GADOLINIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	477 lb _m /ft ³	7.64 g/cm ³
Melting Point.	4720° R	2620° K
Heat of Fusion.		
Heat of Vaporization. . .		
Heat of Sublimation. . .		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
□	455	6.97
Δ	477	7.64

<u>Melting Point:</u>	°R	°K
○	4722 ± 90	2623 ± 50
◇	4686 ± 36	2603 ± 20

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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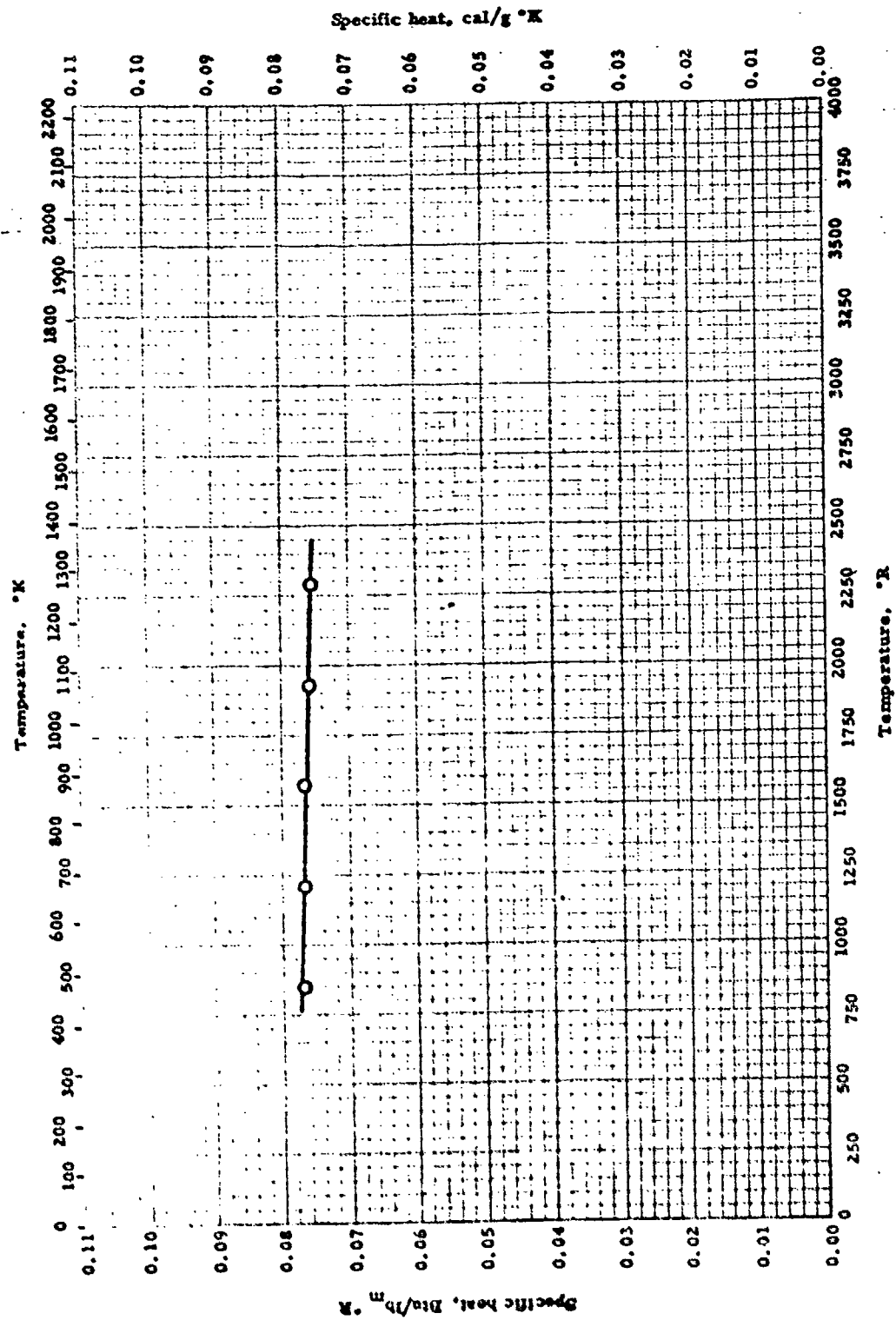
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF CADOLINIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E. and Johnson, J. R.	57-24	4532-4812	Cd ₂ O ₃ ; 2% Tb; 0.5% ea. Ce, Ho, Nd, Sm, Eu, Dy; < 0.05% ea. La, Lu, Er, Yb	MP; observation of first liquid drop; calibrated optical pyrometer sighting on black body cavity	Pressed at 2700 psi; fired 2 hr. at 1300°C
□	Idid.	57-24	Room	Same as above	pt weight and volume by water displacement	Pressed at 2700 psi; fired 2 hr. at 1500°C; sample sintered and cracked
△	Idid.	57-24	Room	Same as above	pt same as above	
◇	Bruch, C. A. and Cashin, W. M.	56-109	4650-4722	Cd ₂ O ₃	MP; observation of first liquid drop on "V" ribbon, calibrated optical pyrometer	



SPECIFIC HEAT -- GADOLINIUM OXIDE (Gd_2O_3)

SPECIFIC HEAT -- GADOLINIUM OXIDE (Gd_2O_3)

REFERENCE INFORMATION

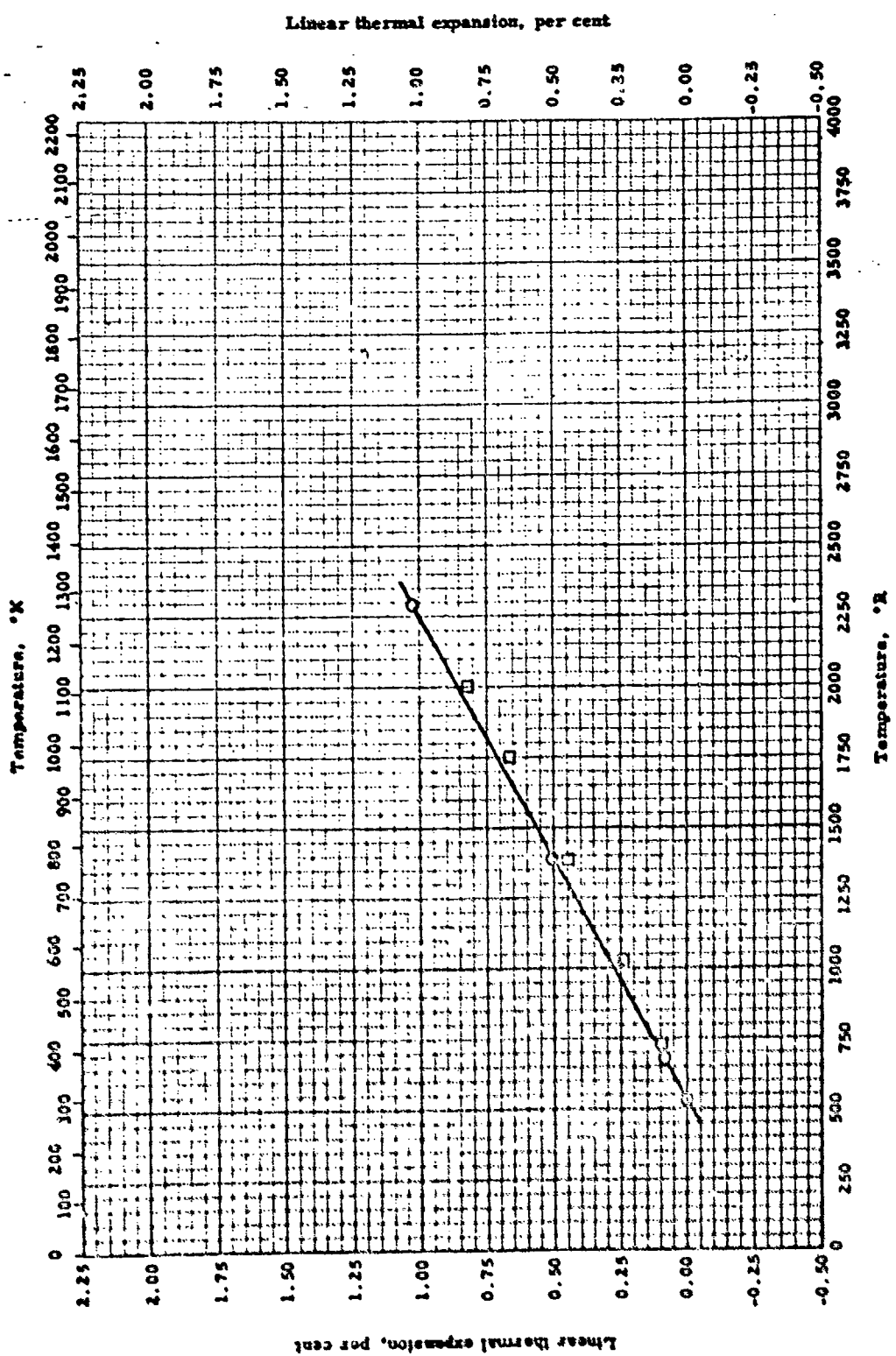
Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., and Johnson, J. R.	57-24	852-2292	2% Tb; 0.5% ea. Ce, Nd, Sm, Eu, Dy	Drop method; ice calo- rimeter	Pressed at 2700 psi, fired 2 hr. at 1300°C

59-324

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LINEAR THERMAL EXPANSION -- GADOLINIUM OXIDE

LINEAR THERMAL EXPANSION--GADOLINIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Curtis, C. E. and Johnson, J. R.	57-24	528-2292	G ₂ O ₃ : 2% Tb; 0.5% each of Ce, Nd, Sm, Eu, Dy.	Not given	Pressed into bars at 2700 psi, fired 2 hrs. at 1500°C. Sintering and cracking were noted.
D	Flores, G. L., Krytynski, C. W. and Dumas, H. E.	57-157	528-2004	Gd ₂ O ₃	Interferometer	Hot pressed at 1800°C in graphite mold to 95% theoretical p.

PROPERTIES OF LANTHANUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	406 lb _m /ft ³	6.51 g/cm ³ *
Melting Point	4470°R	2480°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

*Handbook of Chemistry and Physics (Ref. 59-2)

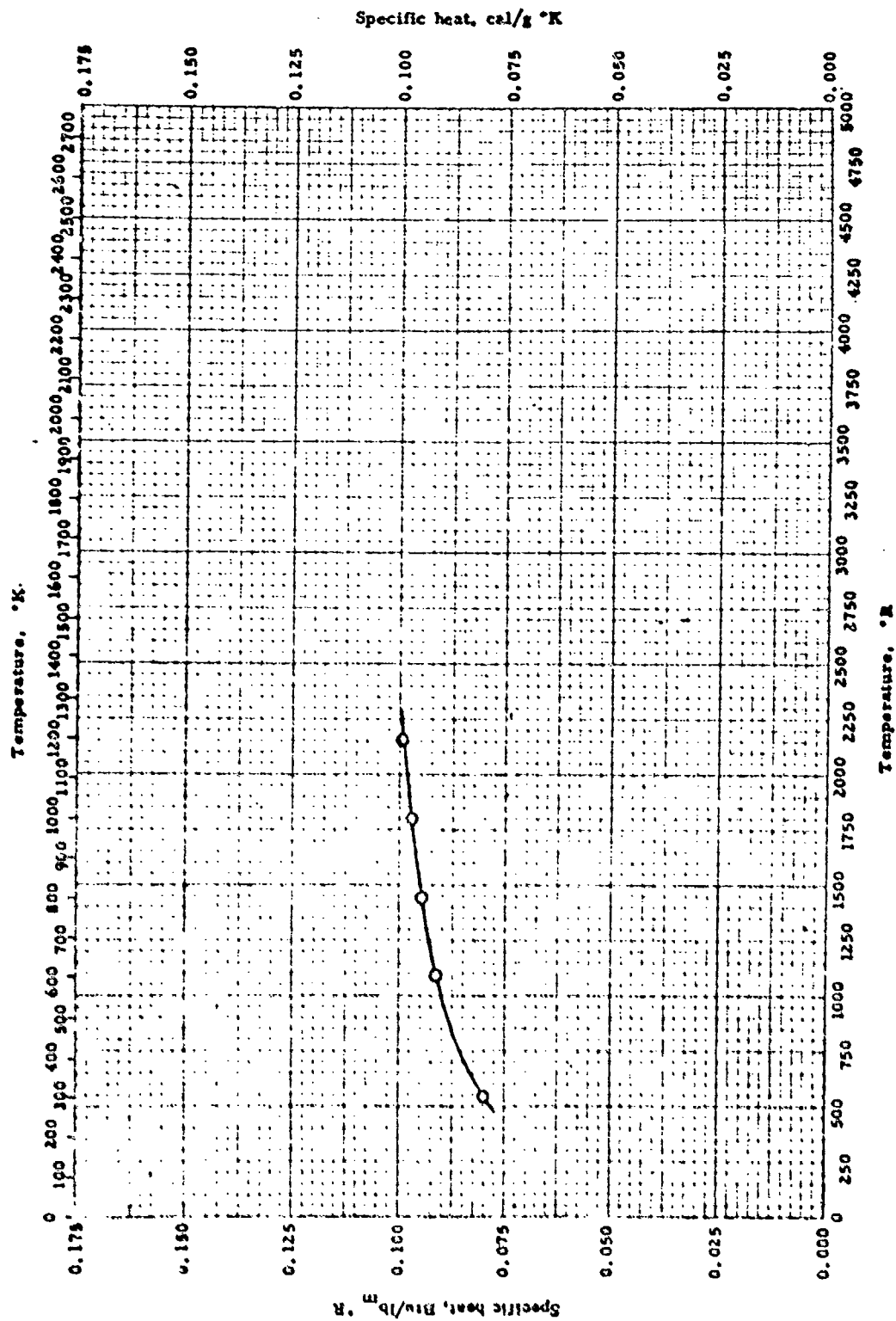
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R O 4470 ± 34	°K 2483 ± 20
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF LANTHANUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Lambertson, W. A. and Gensel, Jr., P.H.	52-131	4434-4506	99% pure lanthana, La_2O_3	MP: inspection after heating in constant temp. furnace, temp. by cali- brated optical pyrometer	



SPECIFIC HEAT -- LANTHANUM OXIDE

59-69

WADC TR 58-476

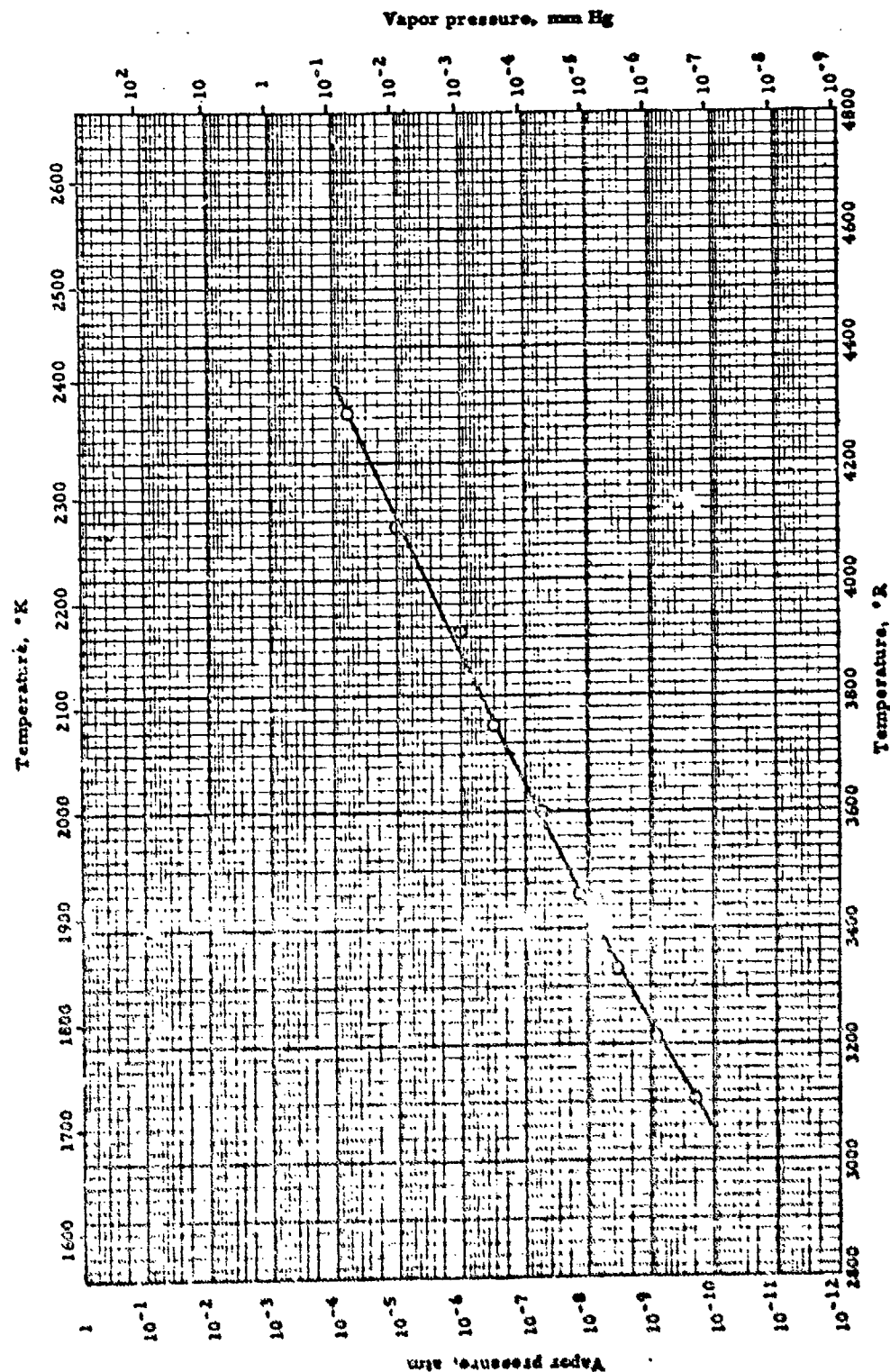
133

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SPECIFIC HEAT -- LANTHANUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Blomke, J. O. and Ziegler, W. T.	51-79	690-2110	Lanthana, La_2O_3	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%



VAPOR PRESSURE -- LANTHANUM OXIDE

VAPOR PRESSURE -- LANTHANUM OXIDE

REFERENCE INFORMATION

Sym Sol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yosim, S. I. and Mills, T. A.	57-145	3103-4286	La ₂ O ₃	Knudsen effusion cell of tungsten	Vapor press. for reaction La ₂ O ₃ → LaO + O ₂ Below 3400°R auth. quote data of others

PROPERTIES OF NEODYMIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	452 lb _m /ft ³ *	7.24 g/cm ³ *
Melting Point	4580 °R	2545 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

Handbook of Chemistry and Physics (Ref. 59-2)

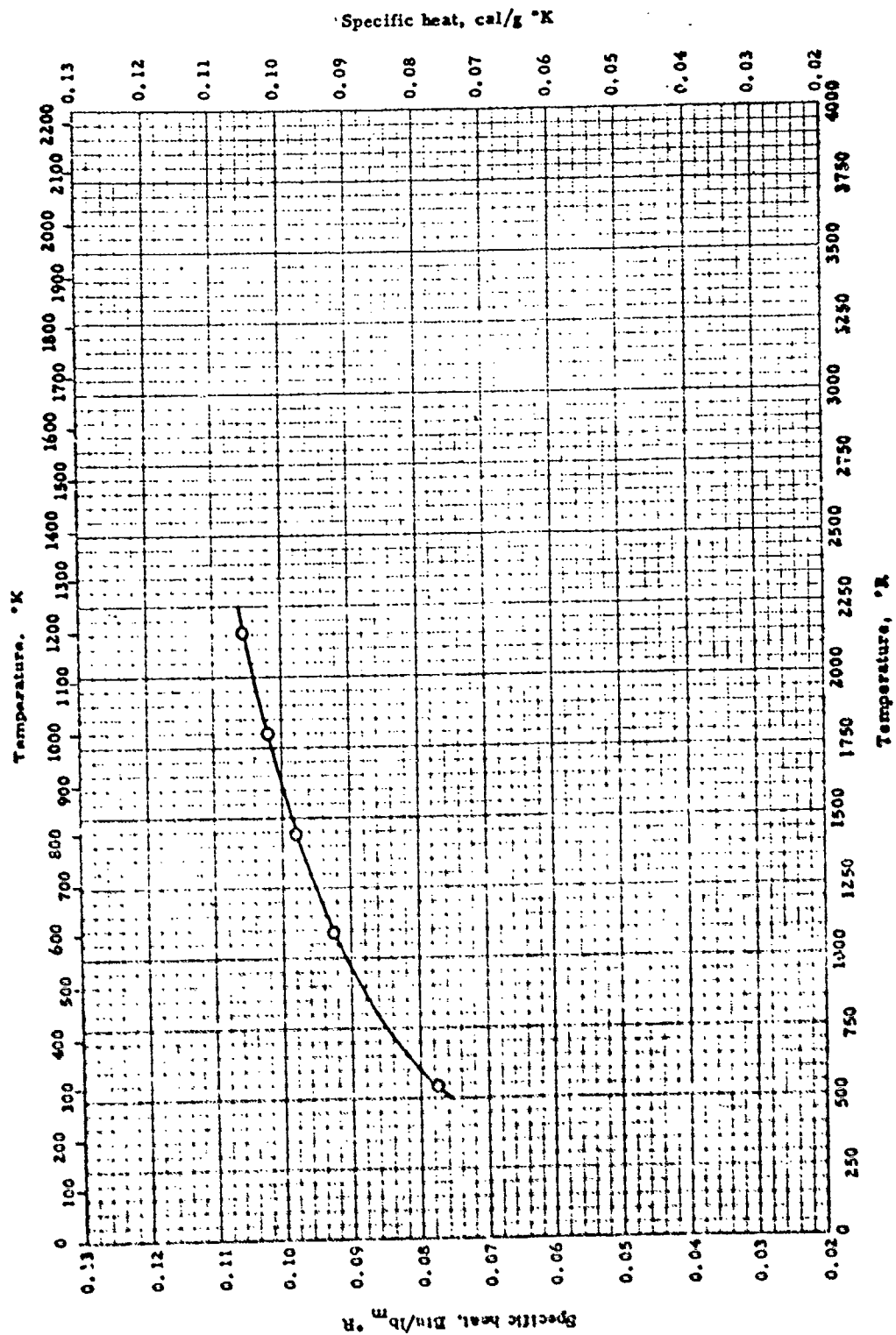
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
	4581 ± 36	2545 ± 20
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF NEODYMIUM OXIDE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
0	Lamberton, W. A. and Gussel, Jr., F. H.	12-131	4545-4617	99% neodymia, Nd ₂ O ₃	MP: by inspection after heating in constant temp. furnace, temp. by calibrated optical pyrometer	



SPECIFIC HEAT -- NEODYMIUM OXIDE

SPECIFIC HEAT -- NEODYMIUM OXIDE

REFERENCE INFORMATION

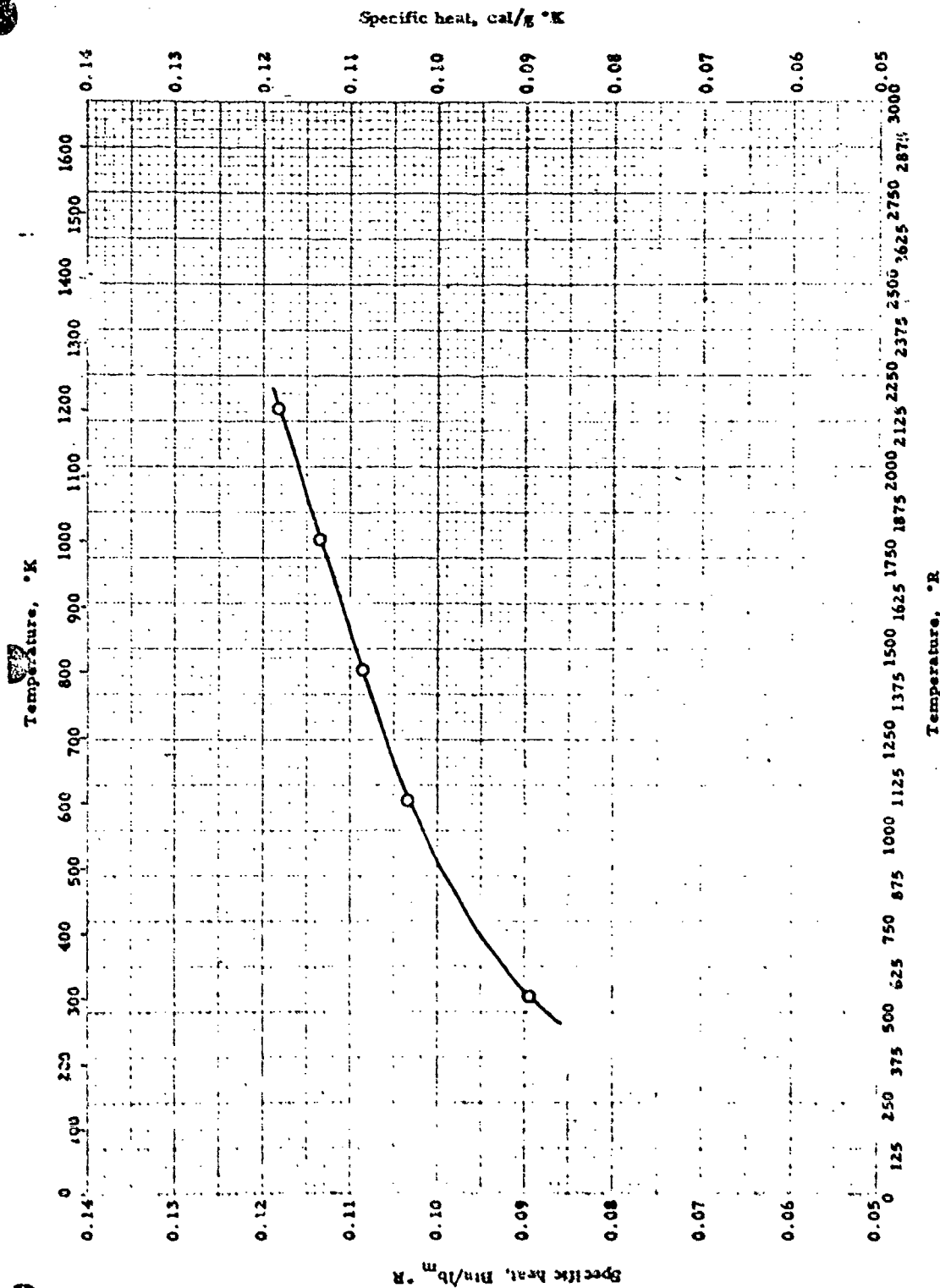
Sym E.S.I.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Biomeke, J. O. and Ziegler, W. T.	51-29	690-2110	99.5% pure Nd ₂ O ₃	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%

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SPECIFIC HEAT -- PHASEODYMIUM OXIDE

SPECIFIC HEAT -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

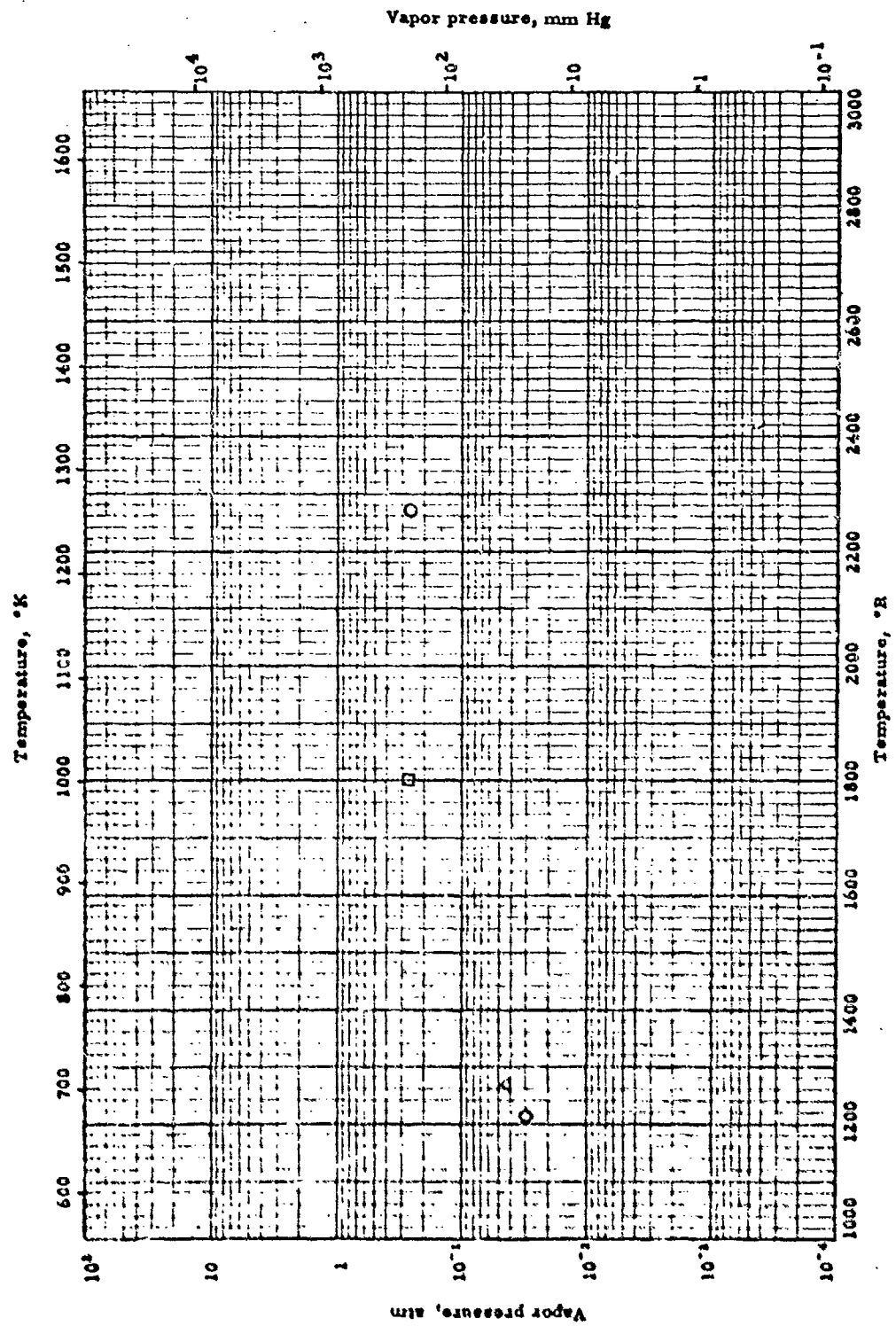
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Blomcke, J. O. and Ziegler, W. T.	51-29	690-2110	99.5% Pr_2O_3	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%

60-674

WADC TR 58-476

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VAPOR PRESSURE -- PRASEODYMIUM OXIDE

VAPOR PRESSURE -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Stubblefield, C. T.	55-151	1212-2292	PrO _{1.703}	Determined equilibrium temp. and pressure of O ₂ over Pr during formation of oxide	Body centered cubic phase, determined by x-ray photograph
○	Did.	55-151	1212-2292	PrO _{1.717}	Same as above	Rhombohedral phase, determined by x-ray photograph
△	Did.	55-151	1212-2292	PrO _{1.804}	Same as above	Face centered cubic phase, determined by x-ray photograph
◇	Did.	55-151	1212-2292	PrO _{1.833}	Same as above	Same as above

PROPERTIES OF SAMARIUM OXIDE + X

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	460 lb _m /ft ³ *	7.4 g/cm ³ *
Melting Point.	4720°R *	2620°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Value for Sm₂O₃.

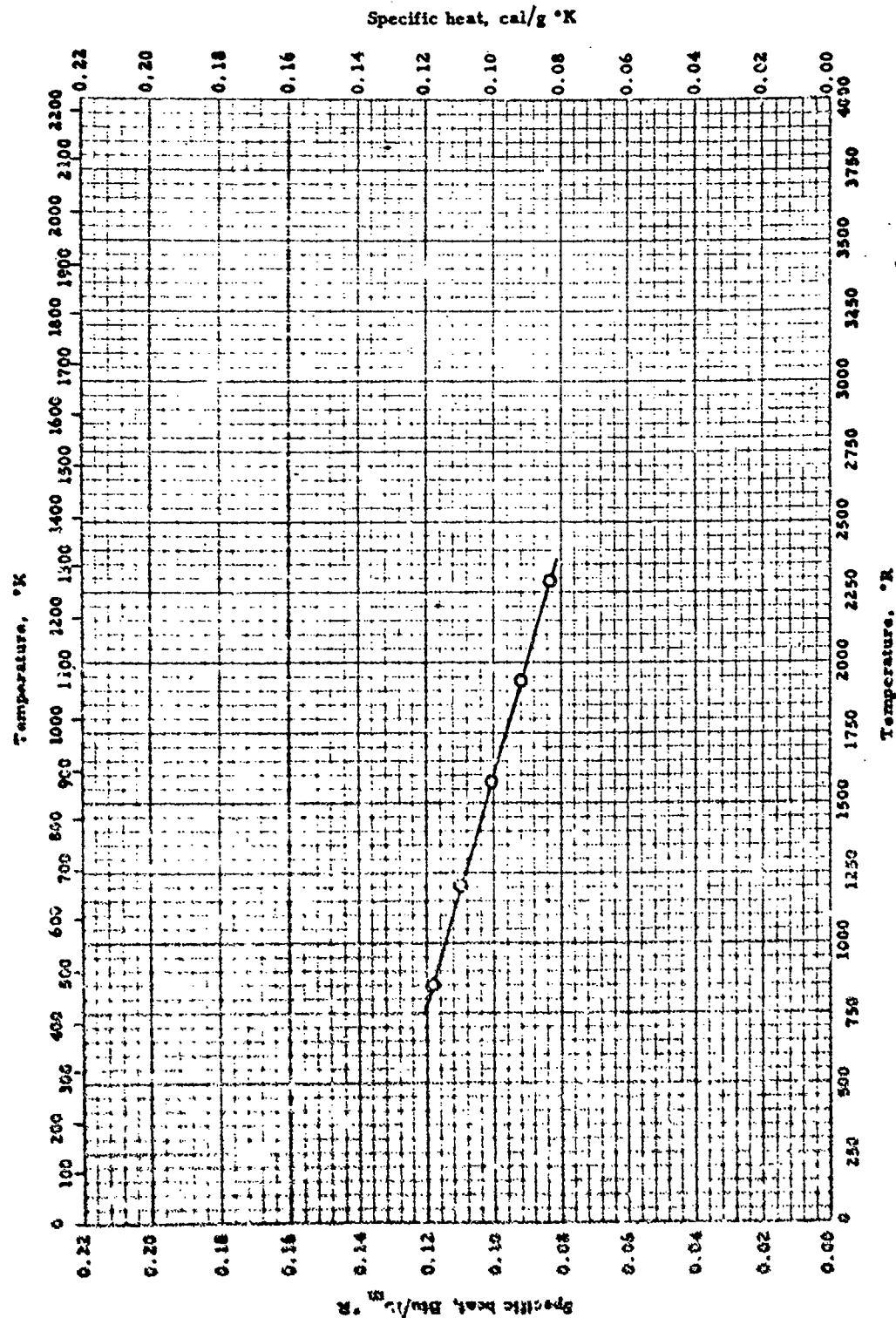
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
□	375	6.3
Δ	462	7.4
▽	412	6.60
<u>Melting Point:</u>	°R	°K
○	4722 ± 90	2623 ± 50
◇	4632 ± 90	2573 ± 50
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF SAMARIUM OXIDE + X

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Curtis, C. E. and Johnson, J. R.	57-24	4632-4812	Sm ₂ O ₃ ; <0.5% Nd; 0.4% Eu; <0.1% Gd; <0.2% ea. Dy, Ho, Er; <0.1% Tb; <0.05% ea. Y, La, Er, Yb	MP; observation of first liquid drop; calibrated optical pyrometer sight- ing on black body cavity	Pressed at 2700 psi; fired 2 hr. at 1300°C
□	Ibid.	57-24	Room	Same as above	p; weight and volume by water displacement	Pressed at 2700 psi; fired 2 hr. at 1500°C; sintered and cracked
△	Ibid.	57-24	Room	Same as above	p; same as above	
◇	Bruch, C. A. and Cashin, W. M.	56-109	4542-4722	Sm ₂ O ₃	MP; observation of first liquid drop on "Y" ribbon calibrated optical pyro- meter	
▽	Curtis, C. E. and Johnson, J. R.	57-24	Room	63.8% Sm ₂ O ₃ ; 26.3% Gd ₂ O ₃ ; 4.8% Dy ₂ O ₃ ; 0.9% Nd ₂ O ₃ ; 4.2% Y ₂ O ₃ and other rare-earth oxides	p; weight and volume by water displacement	Landay commercial mix- ture; 1/4 of mixture pre- calcined at 1400°C; all dry pressed at 4000 p-si; sinter- ed at 1500°C



SPECIFIC HEAT -- SAMARIUM OXIDE (Sm_2O_3)

59-645

WADC TR 58-476

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SPECIFIC HEAT -- SAMARIUM OXIDE (Sm_2O_3)

REFERENCE INFORMATION

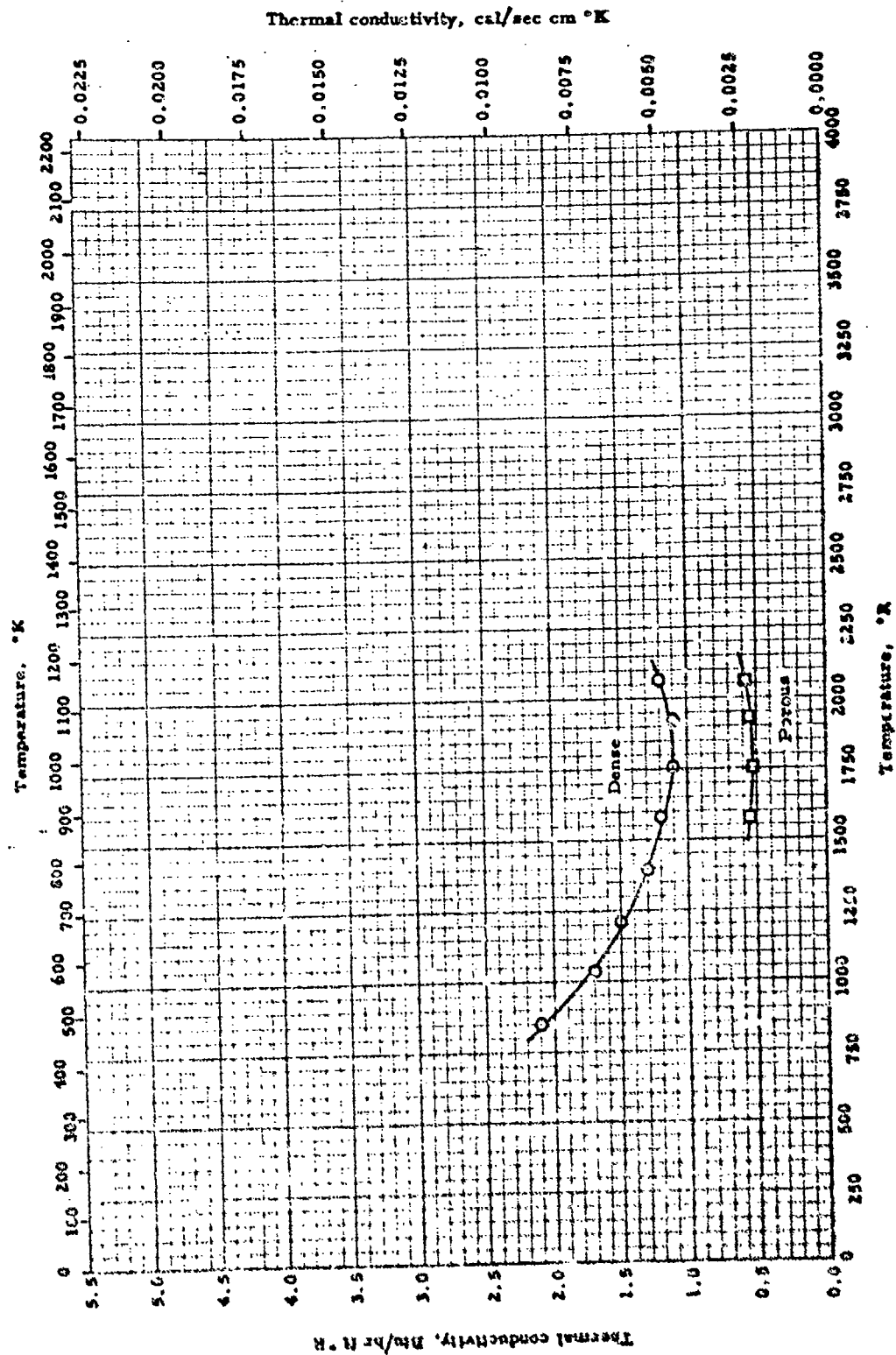
Spec. Sol.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Curtis, C. E. and Johnson, J. R.	57-24	492-2292	<0.5% Nd; <0.4% Eu; <0.3% Gd; <0.2% ea. Dy, Ho, Pr	Drop method; ice calorimeter	

59-480

WAF 58-476

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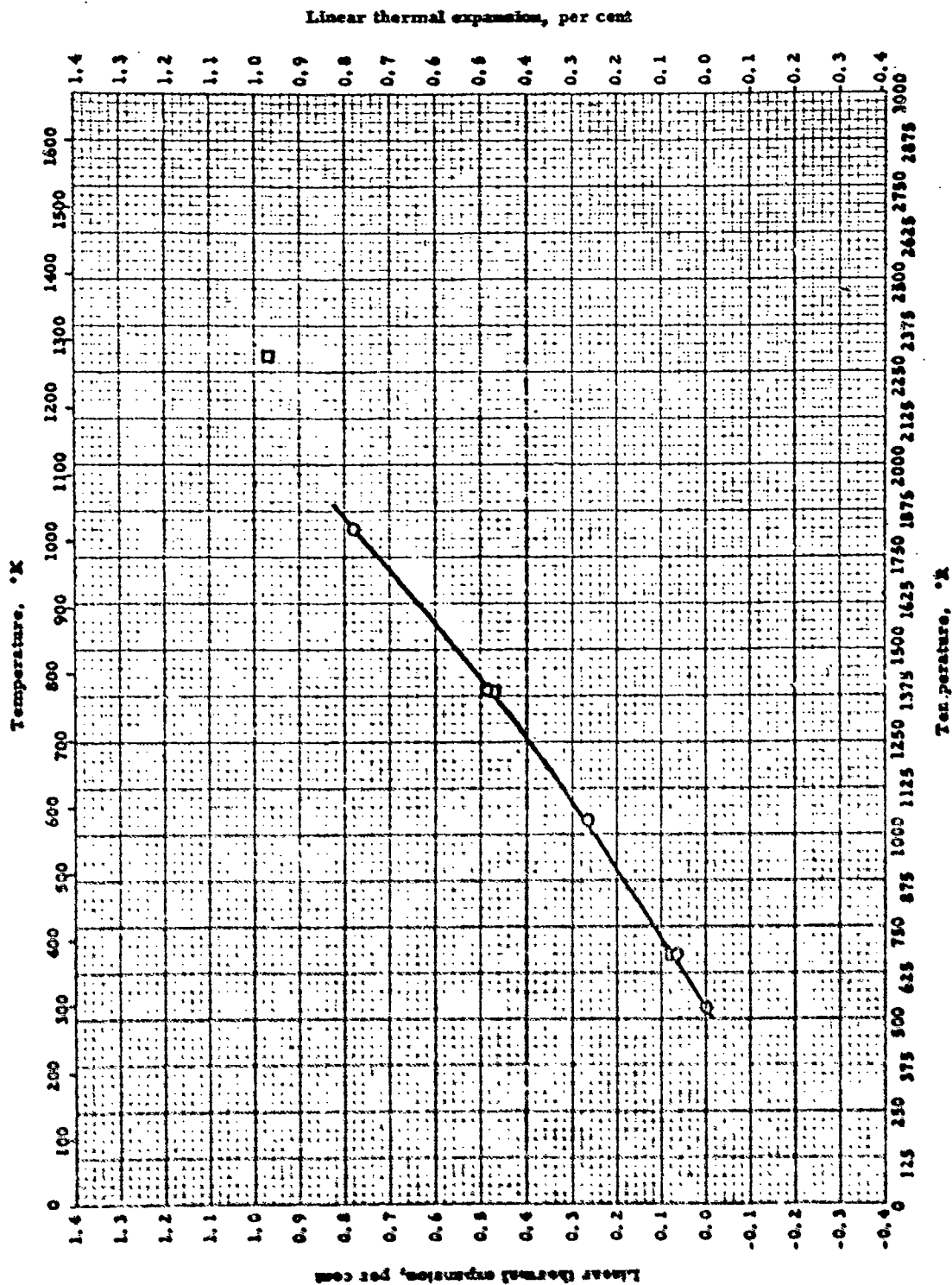


Thermal conductivity -- SAMARIUM OXIDE - GADOLINIUM OXIDE SOLID SOLUTION

THERMAL CONDUCTIVITY -- SAMARIUM OXIDE - GADOLINIUM OXIDE SOLID SOLUTION

REFERENCE INFORMATION

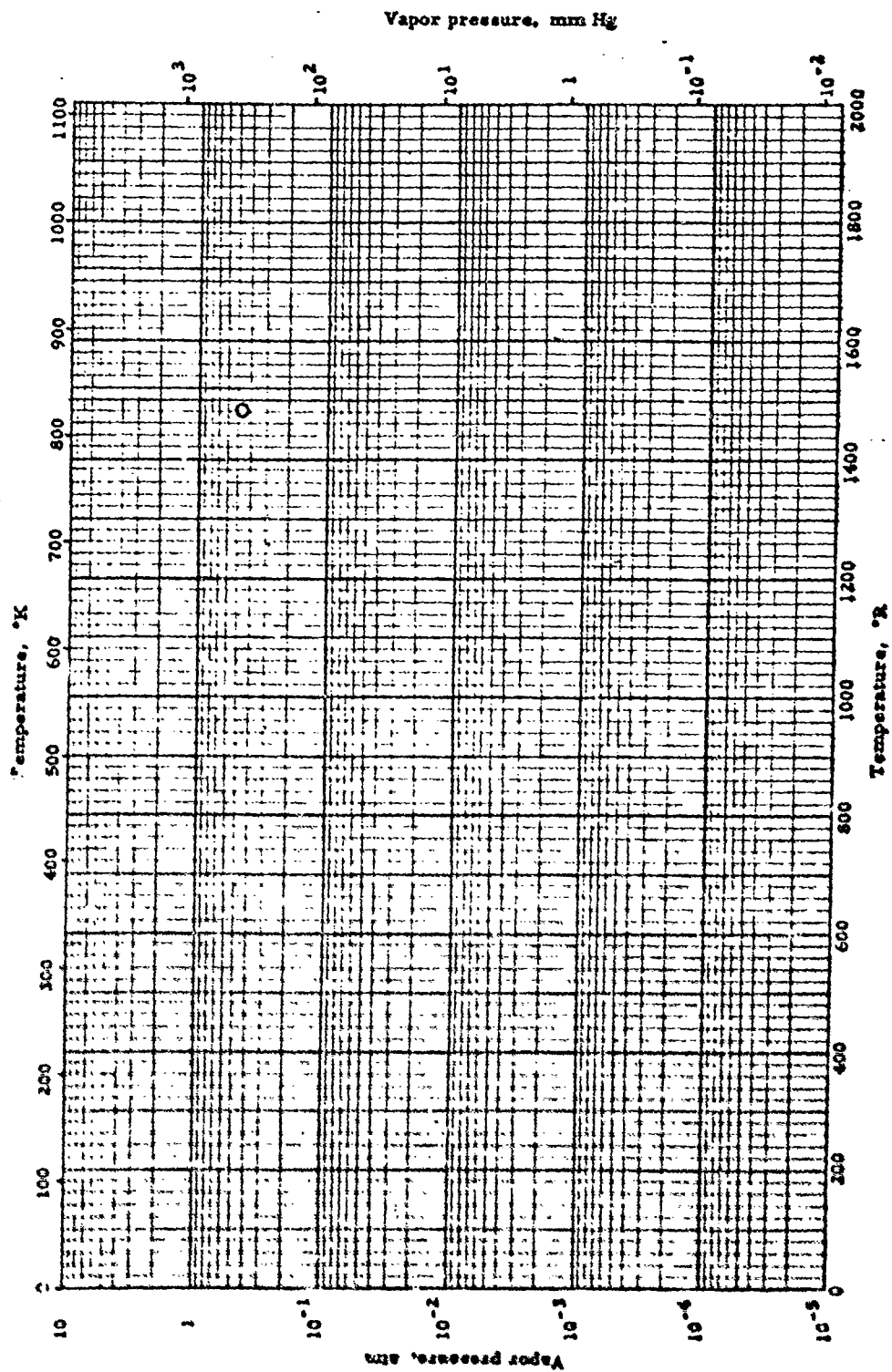
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-53	Kingery, W. D., and Norton, F. H.	55-53	852-2067	Dense sample	Comparative; rods	Fired to dense condition
55-53	Ibid.	55-53	8572-2068	Porous sample	Same as above	Fired to lower temp.; quite porous



LINEAR THERMAL EXPANSION -- SAMARIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Flaetz, G. L., W. Krytynski, C. W. and Dumas, H. E.	57-189	528-1824	Sm ₂ O ₃	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density
□	Curtis, C. E. and Johnson, J. R.	57-24	528-2292	Sm ₂ O ₃ . <0.5% Nd; <0.4% Eu; <0.3% Cd; <0.2% ea.Dy, Ho, Pr	Not given	Pressed at 2700 psi, fired 2 hr. at 1500°C. Sintering and cracking noted at 1500°C



VAPOR PRESSURE -- TERBIUM OXIDE

VAPOR PRESSURE -- TERBIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Smittlefield, C. T.	55-151	1482-1662	TbO _{1.814}	Determined equilibrium temp. and pressure of O ₂ over Tb during preparation of oxide	Face centered cubic phase, determined by x-ray photograph

PROPERTIES OF MAGNESIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	235 lb _m /ft ³	3.77 g/cm ³
Melting Point	5800° R	3220° K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	212	3.39
◇	235	3.77
▽	127	2.04
○	212	3.4

<u>Melting Points:</u>	°R	°K
□	5802	3223
Δ	5532	3073

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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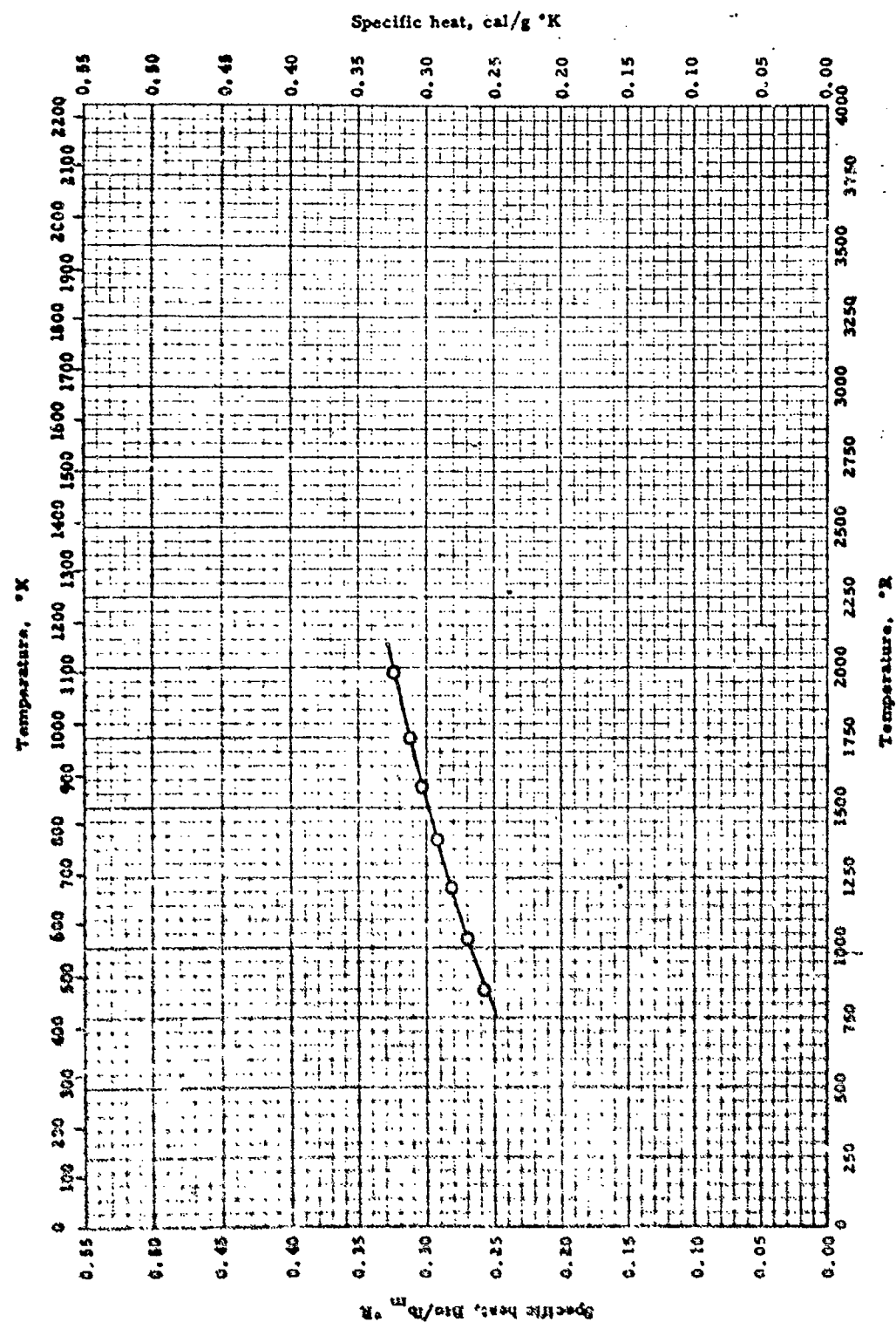
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gangler, J. J.	50-10	Room	60.02% Mg; 39.58% O ₂ ; 0.07% combined C; <0.01% free C	p: weight in air and in distilled water	Auth. quotes theor. density 3.62 g/cm ³ . Samples hot pressed in graphite mold
□	O'Connor, W. F., Lassio, T. S. et al.	51-47	5802	MgO	MP: visual observation; optical pyrometer	
△	Trombe, F.	49-16	5532	MgO	MP: not given	
◇	Johnson, F. D.	50-37	Room	MgO	p: computed from x-ray measurements of lattice	From Mg(OH) ₂ containing 1% ea. Al, Ca, Na; >0.01% ea. Fe, B, K, <0.01% ea. Cu, Si. Calcined 1 hr at 1000°C, pressed at 52,000 psi
▽	Ibid.	50-37	Room	Same as above	p: not given	Same as above
○	Ibid.	50-37	Room	Same as above	p: same as above	Same as above, but also fired at 1900°C



SPECIFIC HEAT -- MAGNESIUM OXIDE

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SPECIFIC HEAT -- MAGNESIUM OXIDE

REFERENCE INFORMATION

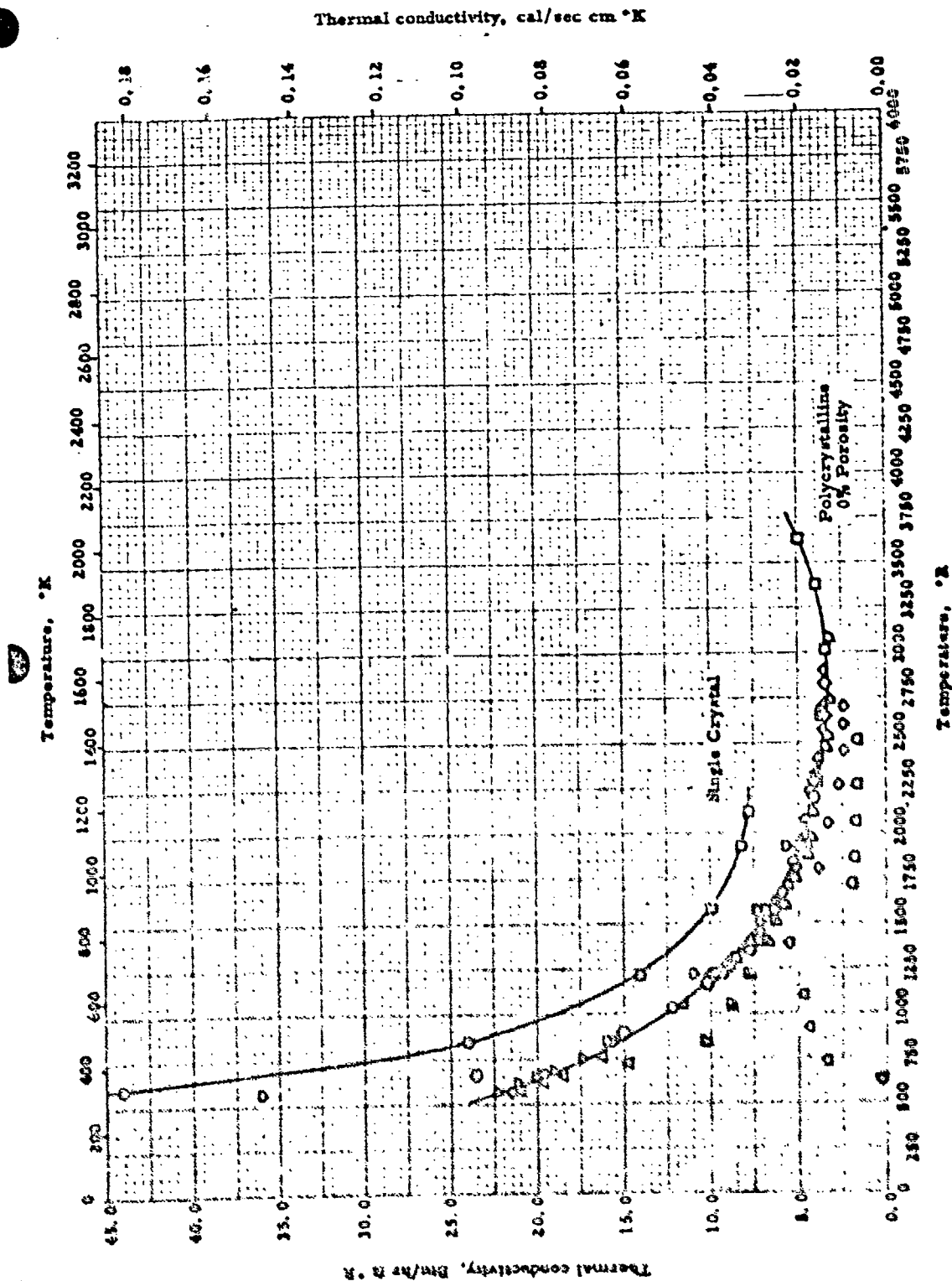
Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Arthur, J. S.	50-7	852-1936	Magnesia, MgO	Modified drop method; sample transferred manually from furnace to calorimeter	Doubtful accuracy

59-742

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Thermal conductivity -- MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE

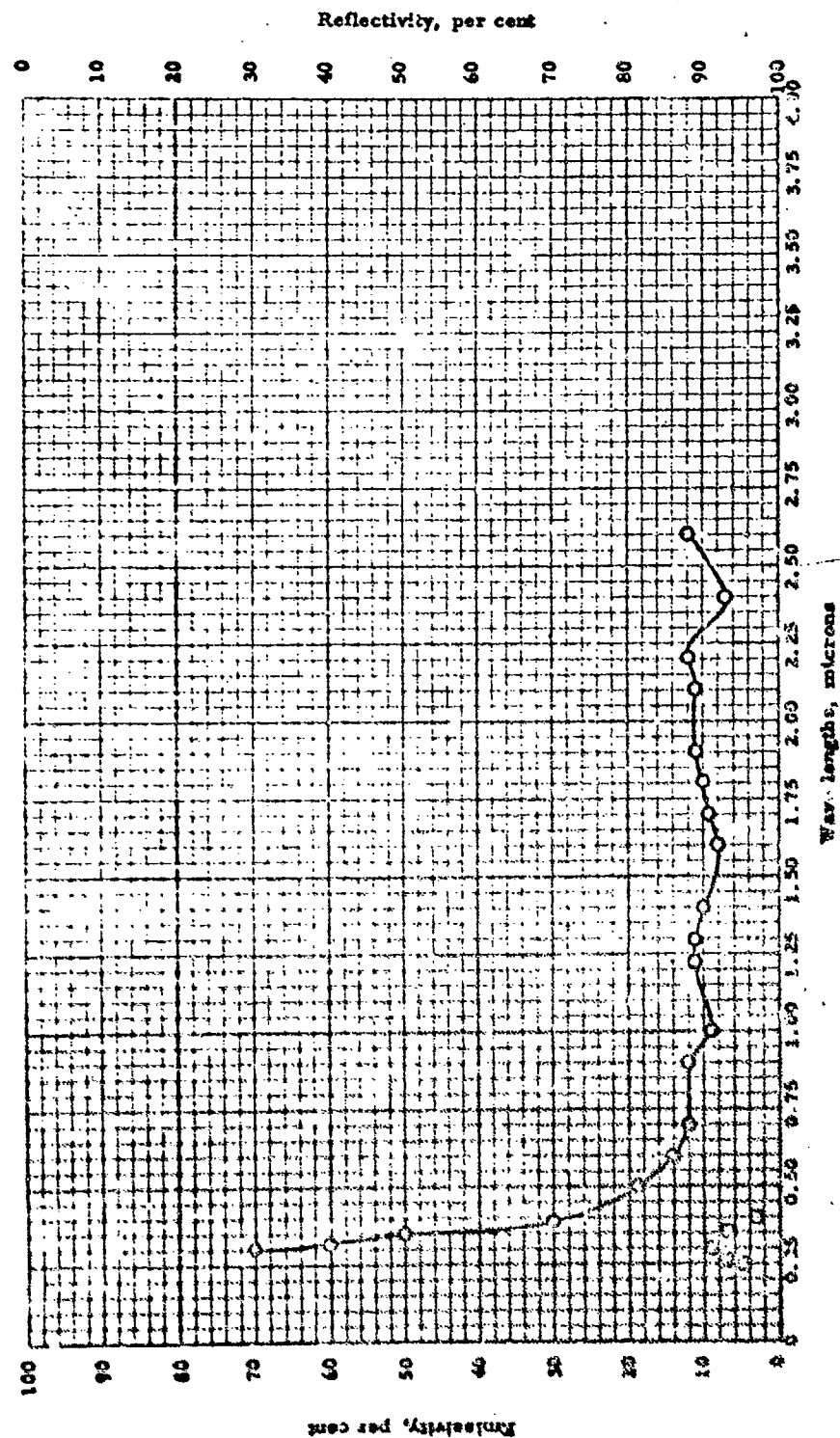
REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	French, J. and Kingery, W. D.	54-6 also 53-67 52-66	582-1662	$\rho = 217 \text{ lb}_m/\text{ft}^3$; zero apparent porosity	Comparative; rods	Slip cast from suspension of finely ground material
□	McQuarrie, Malcolm	54-3 also 52-55 53-67	2292-3642	Prepared from 99.16% MgO; 0.35% CaO; 0.30% SiO ₂ ; 0.14% Al ₂ O ₃ ; 0.05% Fe ₂ O ₃	Prolate spheroidal envelope	Slip cast from ground powder
◇	Adams, Milton	54-5 also 53-67	1212-2832	$\rho = 203 - 205 \text{ lb}_m/\text{ft}^3$; porosity 8.1 - 8.9%	Prolate spheroidal envelope	Slip cast from suspension of finely ground material
△	New Jersey Ceramic Research Station	53-3	568-754	$\rho = 200 \text{ lb}_m/\text{ft}^3$	Comparative; rods (Cu standard)	Made from spectroscopically pure MgCO ₃ ; tested in vacuum
▽	New Jersey Ceramic Research Station	53-4	567-752	97.5% MgO; 2.5% Ta ₂ O ₅ ; $\rho = 217 \text{ lb}_m/\text{ft}^3$	Comparative; rods (Cu standard)	Fired 1 hr. at 2400°F; tested in vacuum
○	Whittemore, Jr., O. J.	49-1	1710-2310	$\rho = 175 \text{ lb}_m/\text{ft}^3$; total porosity = 36%; apparent porosity = 19%	Flat plate; liq. calorimeter	Periclase product made from 6 mesh and finer grain; fired at 3230°F
○	Garval, F. R. and Kingery, W. D.	57-53	492-2292	Single crystal: 0.05% total MgO, CaO, K ₂ O; 0.02% SiO ₂ ; 0.01% Fe ₂ O ₃	Comparative; rods (Al ₂ O ₃ cube standards)	Data corrected to zero porosity
○	Ibid.	57-53	492-2292	Polycrystalline; average crystal size 8 μ ; porosity = 6.75%	Same as above	Same as above
○	Ibid.	57-53	492-2292	Polycrystalline; average crystal size 12 μ ; porosity = 13.7%	Same as above	Same as above
○	Kaspp, W. I.	43-11	735-1390	Synthetic periclase, isotropic	Comparative; rods; stainless steel cube standard	Data corrected to zero porosity
△	Norton, F. H., Kingery, W. D. et al.	54-144	1032-2652	MgO	Ellipsoidal envelope	Conductivity increased during 4 runs for 1 specimen
▽	Norton, F. H. et al.	50-66	1549-2699	MgO	Oblate ellipsoidal envelope	Sample developed crack. Auth. est. accuracy $\pm 5\%$ for ellipsoid.
▽	Norton, F. H. and Kingery, W. D.	51-75	830-3010	MgO	Two methods: B - comparative, rods (alumina standard) D - ellipsoidal envelope	

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Norton, F. H. et al.	51-76	1199-2737	0.35% CaO; 0.30% SiO ₂ ; 0.14% Al ₂ O ₃ ; 0.03% Fe ₂ O ₃ ; 0.00% Mn; 0.03% TiO ₂	Not given	Hydrostatically pressed at 30,000 psi
Norton, F. H.	51-77	1211-2432	MgO	Ellipsoidal envelope	Auth. est. accuracy $\pm 20\%$ max.
Mannville, R.	53-137	436	MgO pressed powder; $\rho = 1.5 \text{ lb./in.}^3$	Stacked glass lucite standard	Samples pressed at 50,000 psi



SPECTRAL EMISSIVITY - MAGNESIUM OXIDE

59-11118

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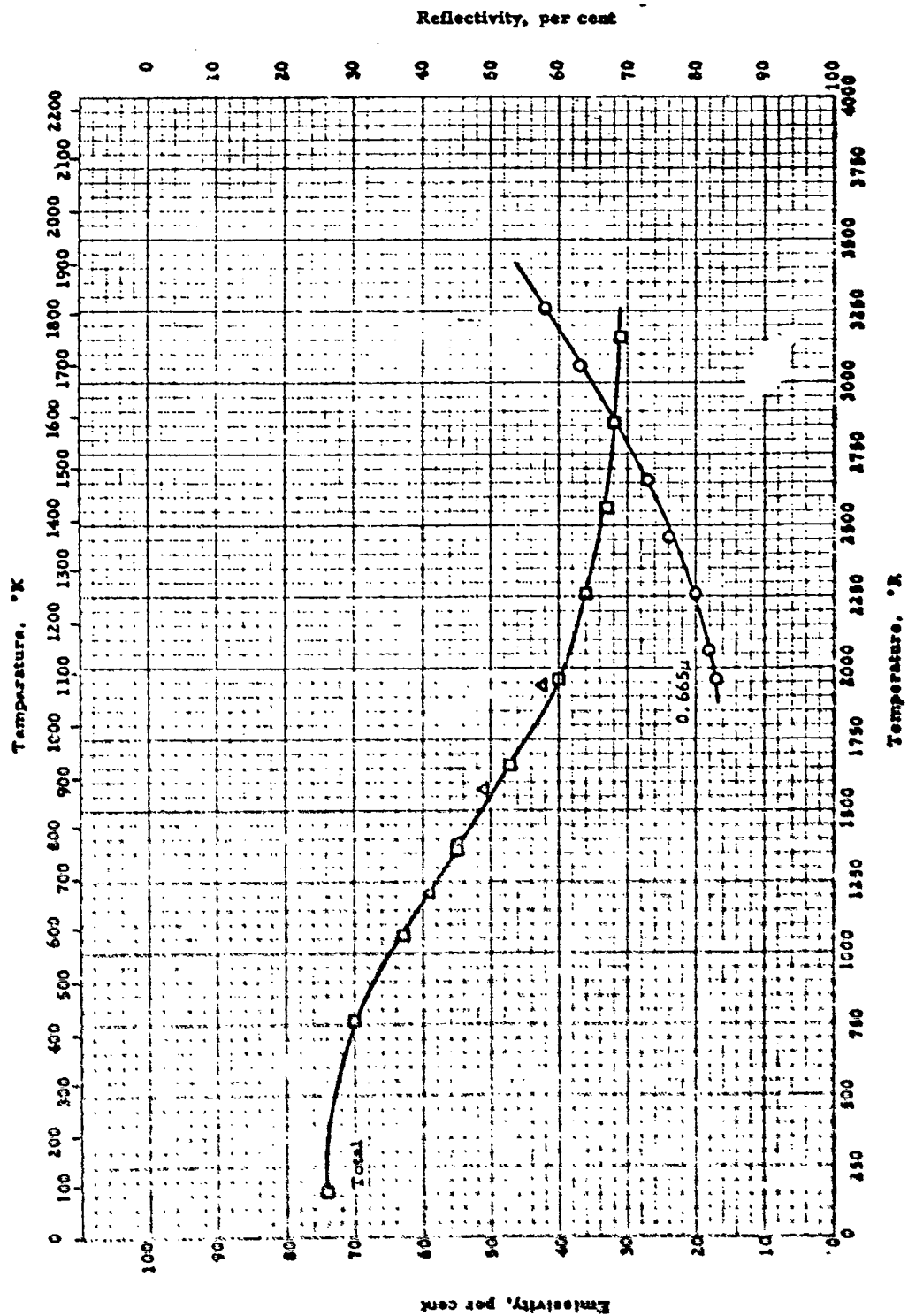
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SPECTRAL EMISSIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
0	Betz, H. T., Clem, O. H., et al.	57-8	Room	Bureau of Standards refractory	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	
□	Beckford, F., Schwarz, S. and Lloyd, G. B.	48-35	Room	Magnesia	Spectral reflectivity: Part-sphere method with 5/6 and 4/6 spheres UV arc on Rowland grating, 9 stage photomultiplier of low stability.	



EMISSIVITY -- MAGNESIUM OXIDE

EMISSION -- MAGNESIUM OXIDE

REFERENCE INFORMATION

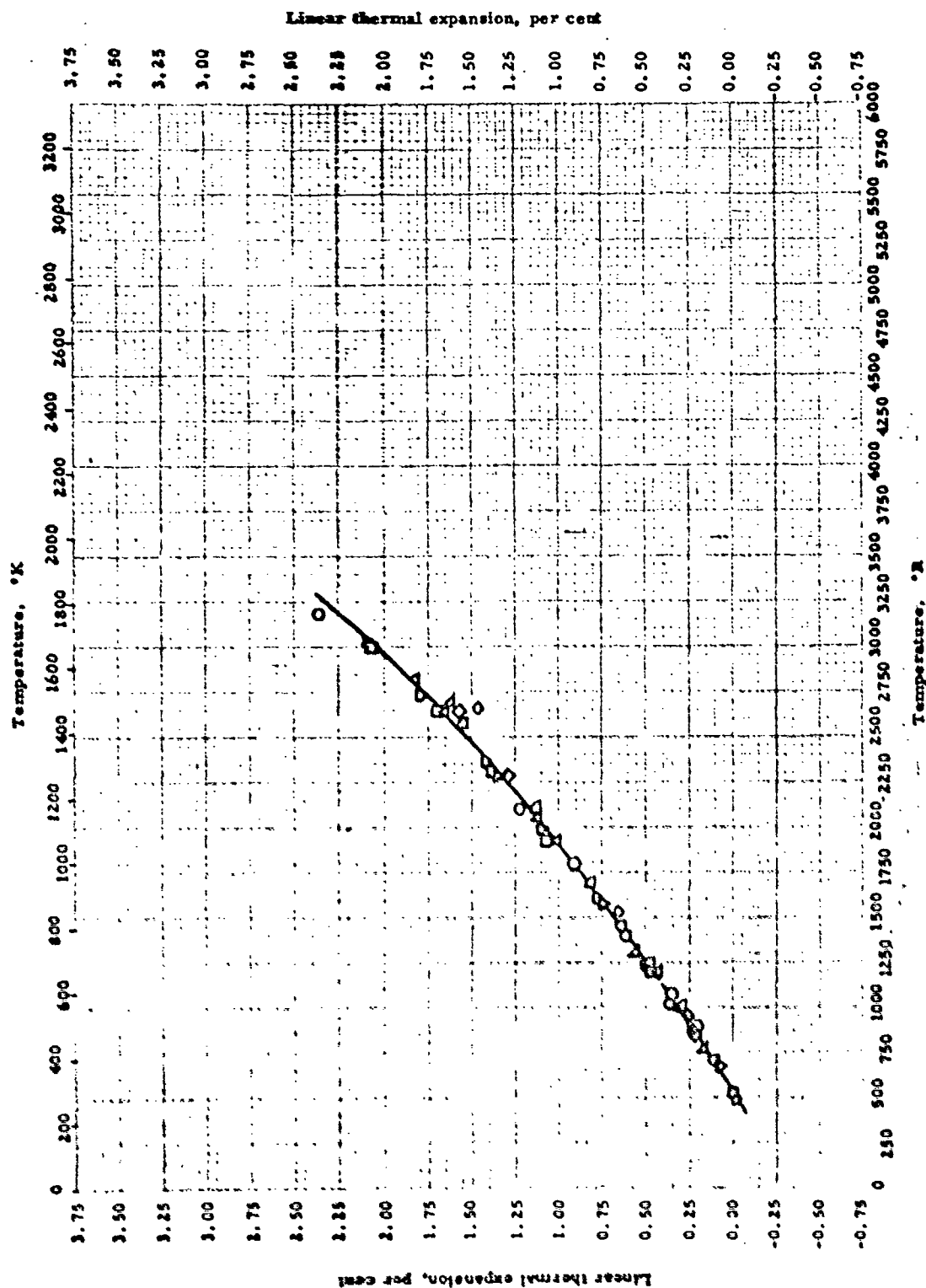
Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Olsen, O.H. and Morris, J.C.	59-1 also 58-1	1960-3260	Fused	Spectral normal emissivity at 0.665μ: comparative: surface brightness compared with that of a black body hole, disappearing filament optical pyrometer; sample temp. by thermocouple	
Q	D14.	59-1 also 58-1	160-3160	Same as above	Total normal emissivity: comparative; radiant heat flow compared with that of a black body, thermopile; sample temp. by thermocouple	
A	Sully, A.H., Brandes, E.A. and Waterhouse, R.E.	52-81	1212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by Pt-Rh thermocouple	

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LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE

REFERENCE INFORMATION

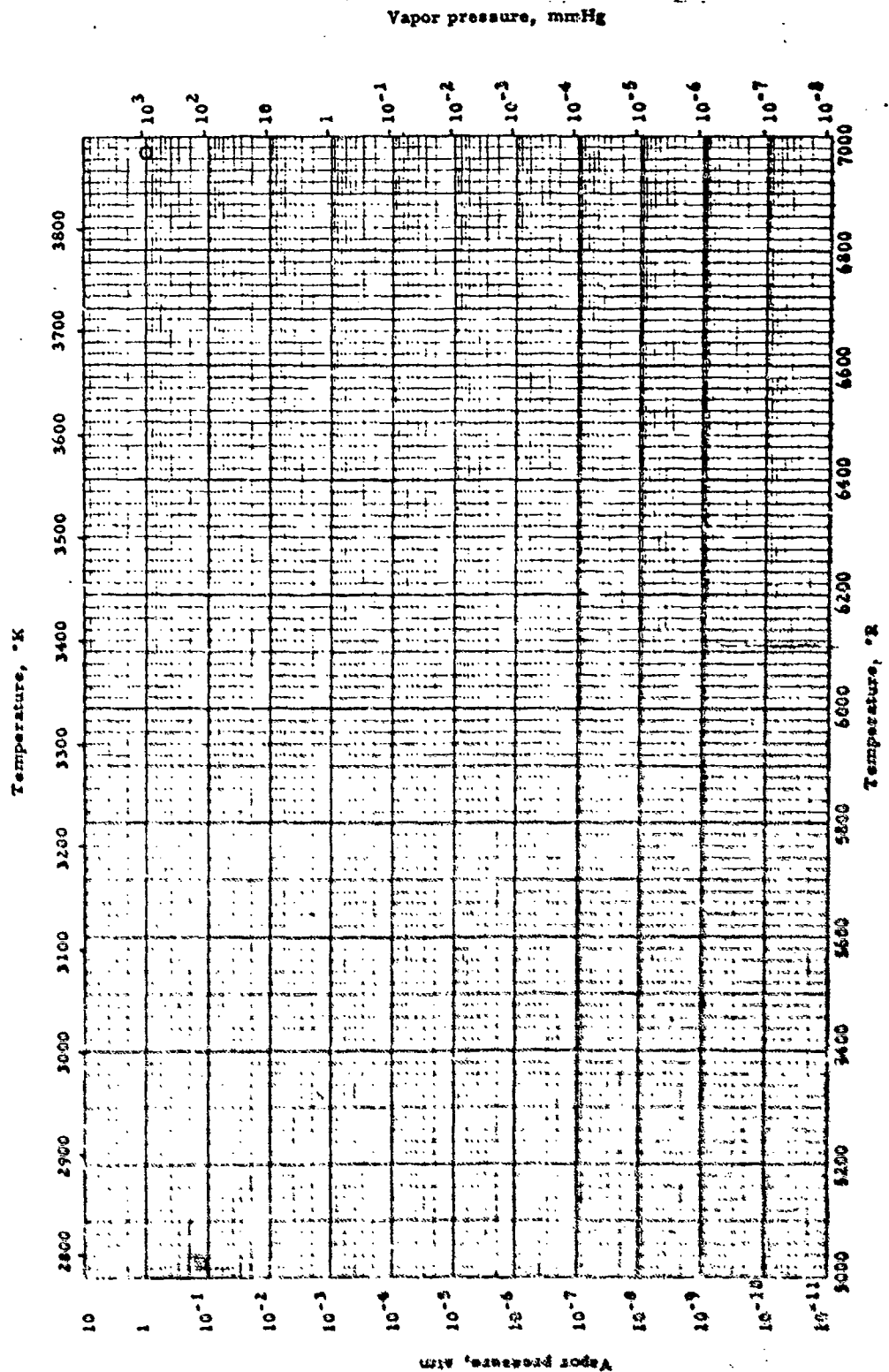
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, M. N.	54-7	1032-3192	Coarse fused grain MgO	Telemicroscopes sight- ing on sample	
□	Crandall, W. B.	52-400	528-3012	Single crystal MgO	Meas. variation in light intensity through parallel line gratings due to movement of one relative to the other	
△	Schwartz, B.	52-11	537-2832	Made from fused refractory grains ($<1\%$ imperurities)	Telemicroscopes sight- ing on sample	Slip cast, dried, fired at 1150°C, machined, ma- chined 3 hr. at 1830°C
◇	Beale, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade MgO	X-ray back reflection	Cast
▽	Trombe, F.	49-16	528-2292	"Pure" MgO	Not given	Auth. est. accuracy $\pm 0.5\%$
○	Stinner, B. J.	57-21	540-1800	Synthetic periclase	X-ray diffraction	
○	Gaugler, J. J.	50-10 also 49-20	1535-1460	60.2% Mg; 39.5% O ₂ ; 0.07% combined carbon; $< 0.01\%$ free carbon. $p =$ 211.5 lb _H /in ²	Interferometer	
○	Mauer, F. A. and Bols, L. H.	55-58	492-3019	99.6% MgO	X-ray diffraction	
○	Kingery, W. D.	57-33	528-2292	Not given	Not given	
○	Pole, C. R., Steinlich, A. W. and Gilbert, N.	46-14	528-2652	97.5% electrically fused MgO; 2.5% sea-water MgO. Fired to 1450°C; Porosity = 31%, $p =$ 151 lb _H /in ² . Fired to 2100°C; Porosity = 19%, $p = 177$ lb _H /in ²	Not described here, refers to others	Fired. Heated at 4°C/min
△	Zimmerman, W. F. and Allen, A. W.	56-164	528-2621	MgO	X-ray back reflection	High purity
◇	Didd.	56-164	528-2639	MgO	Same as above	Dead burned Magnesite (MgCO ₃)

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VU-A-5-A

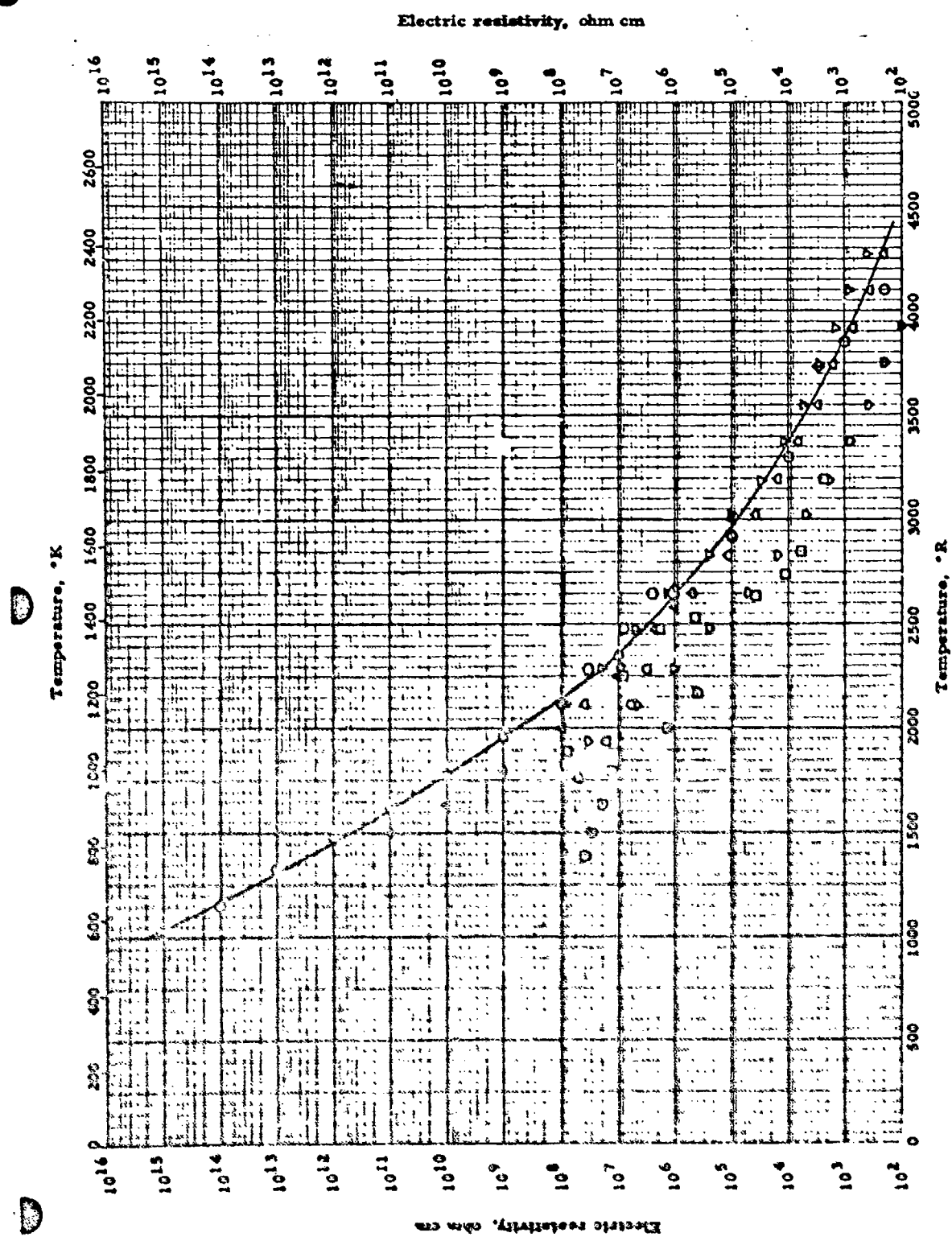


VAPOR PRESSURE--MAGNESIUM OXIDE

VAPOR PRESSURE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Trombe, F.	49-16	6972	MgO	Not given	

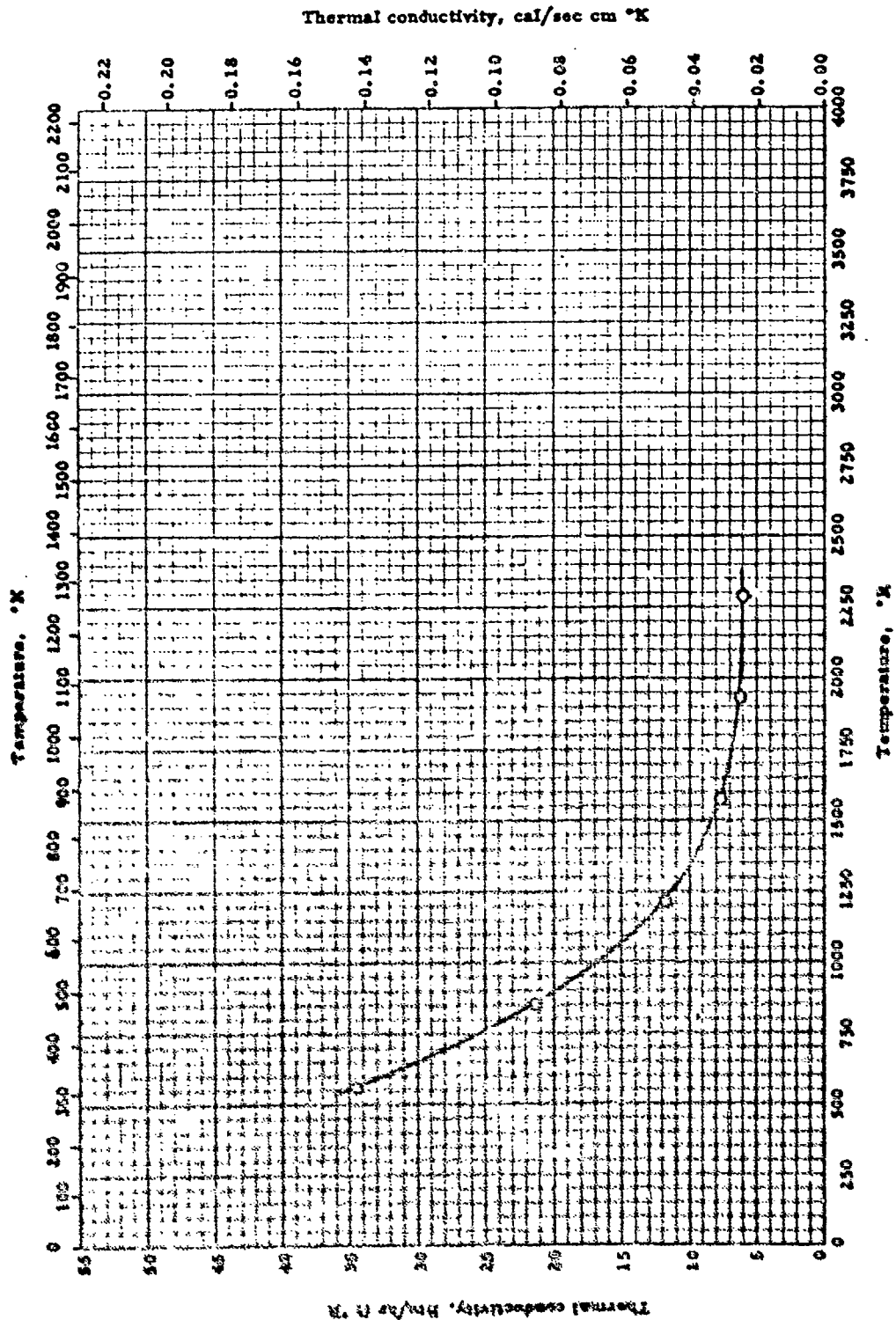


ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE

ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Wiegelt, W. and Hasse, G.	54-94	1032-4092	"Very pure"	Potential drop: sample temp. by calibrated Pt-Rh thermocouple	Burned 99.99% pure Mg in purified O ₂ powder mixed with conductivity water and sintered in high vacuum
H. Weber, J. R. and Henry, E. C.	53-95	1872-1192	10% MgO: c.p. grade	Wheatstone bridge	Calcined at 1000°C fired 10 hr. to 1500°C
Massalski, R.	52-102	1200-3020	MgO	Potential drop	Sintered 14 hr. at 1500°C. Density 70% greater than calculated from X-ray measurements
Treubner, F.	69-14	2652-3722	MgO	Not given	Compressed at 430 psi and calcined at 2100°C
Peck, M.	62-10	1752-4272	"Pure" $\rho = 174 \text{ lb}_m/\text{ft}^3$	Potential drop: sample temp. by optical pyrometer	Compressed at 430 psi and calcined at 1200°C
Did.	62-10	1752-4272	"Pure" $\rho = 62 \text{ lb}_m/\text{ft}^3$	Same as above	Hydrated, compressed at 430 psi
Did.	62-10	1752-4272	"Pure" $\rho = 62 \text{ lb}_m/\text{ft}^3$	Same as above	Cast
Did.	62-10	1752-4272	"Pure" $\rho = 234 \text{ lb}_m/\text{ft}^3$	Same as above	Cast industrial grade
Did.	62-10	1752-4272	97.5% MgO: 2% ZnO: $\rho = 233 \text{ lb}_m/\text{ft}^3$	Same as above	Prepared from chemically pure materials. Calcined for 2 hr.
Nakhsodanov, A. P.	56-73	1372-2170	MgO, polycrystalline	Potential drop, temp. by Mo-Ni thermocouple	



THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

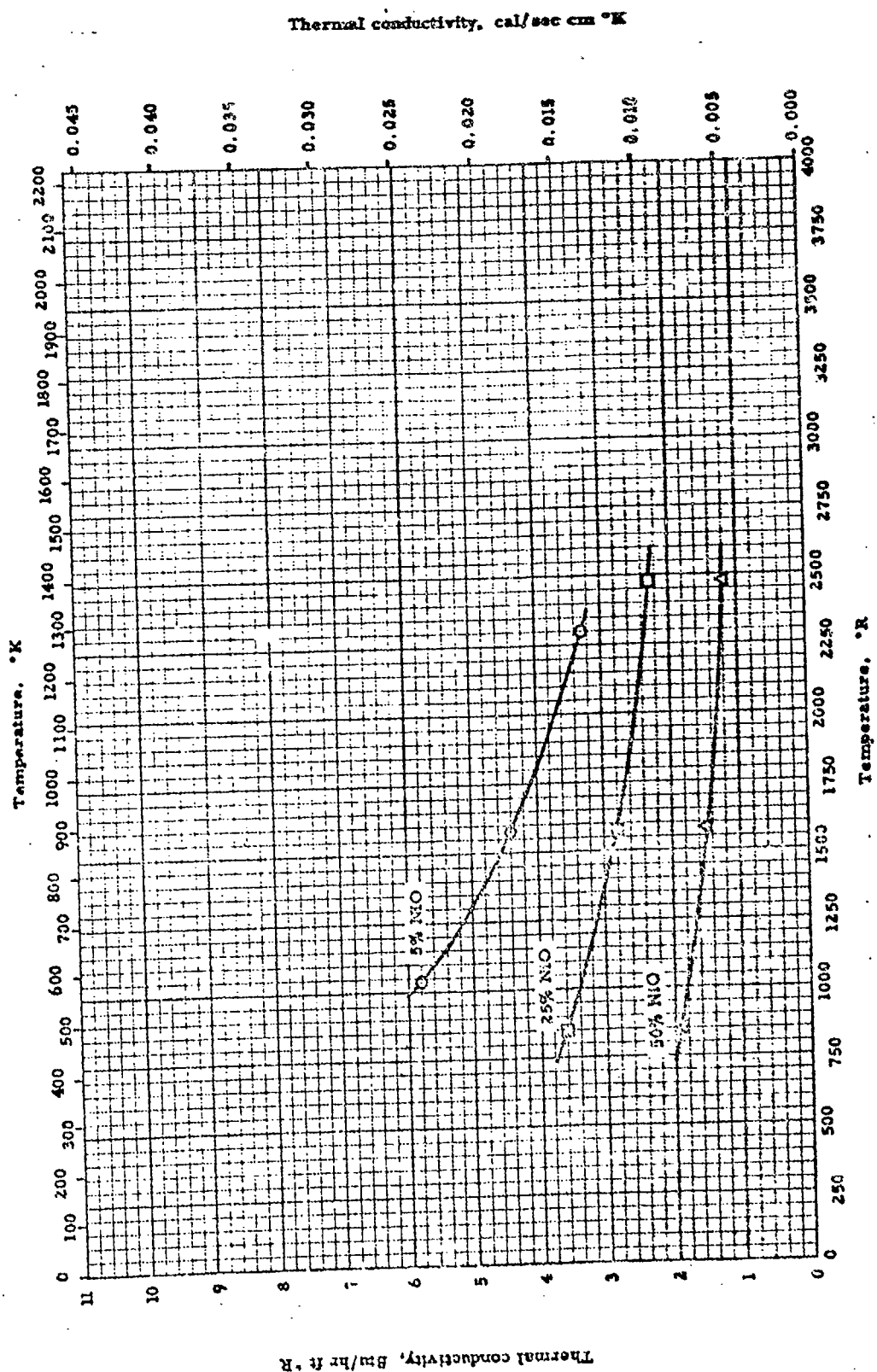
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THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

SYN No.	Investigator	Ref.	Range, °K.	Material Composition	Test Method	Remarks
O	Morton, F. H. and Kingsley W. D.	54-142	564-2292	50% MgO; 50% BeO; bulk $\rho = 152$ lb_m/ft^3 at 25.7% porosity	Ellipsoidal envelope	Slip cast. Data corrected to zero porosity by auth.



THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

REFERENCE INFORMATION

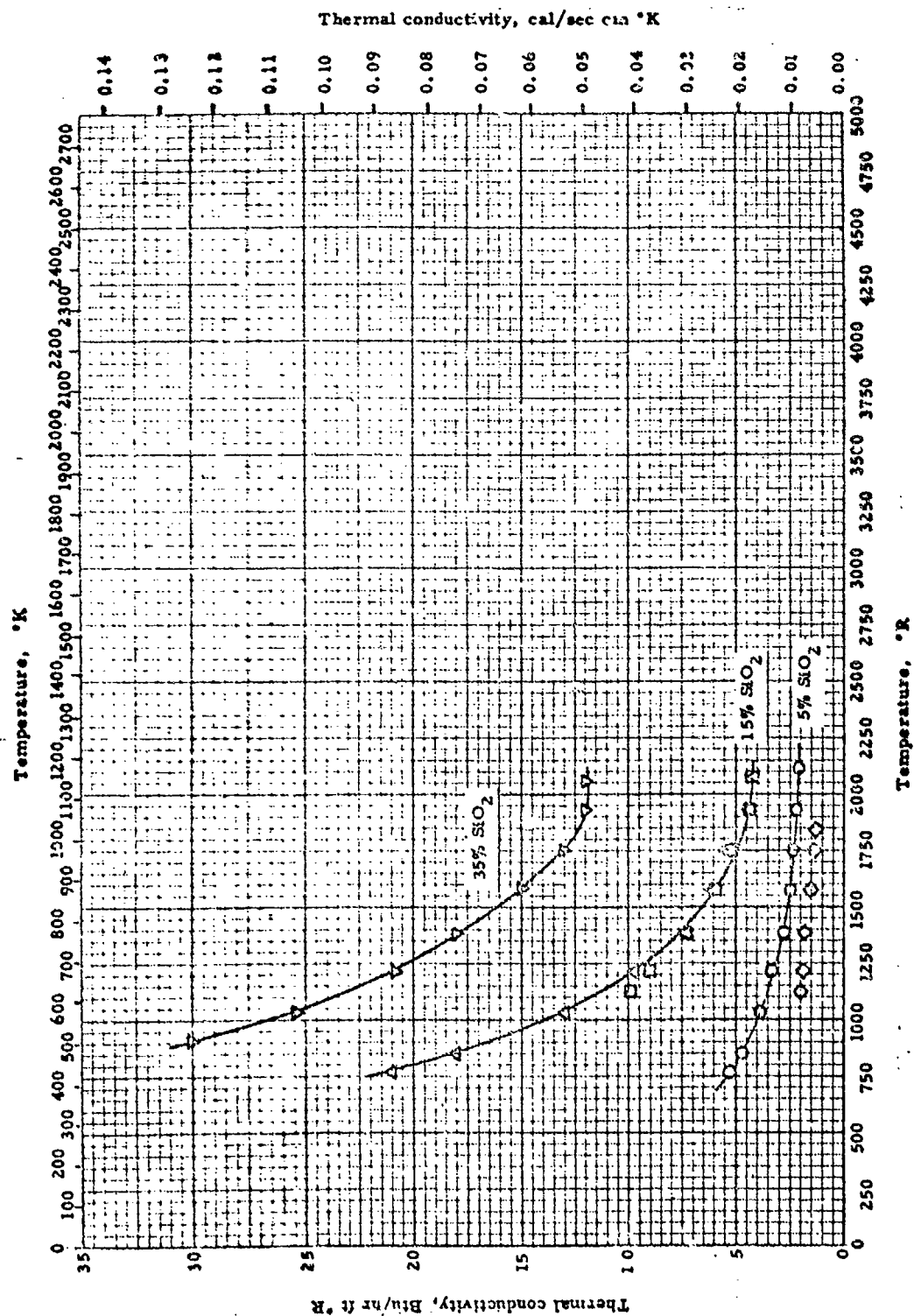
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-1441032-2292	Norton, F. H., Kingery, W. D. et al.		5% NiO	Ellipsoidal envelope	Data corrected to zero porosity by auth.
54-144852-2472	Ibid.		25% NiO	Same as above	Same as above
54-144852-2472	Ibid.		50% NiO	Same as above	Same as above

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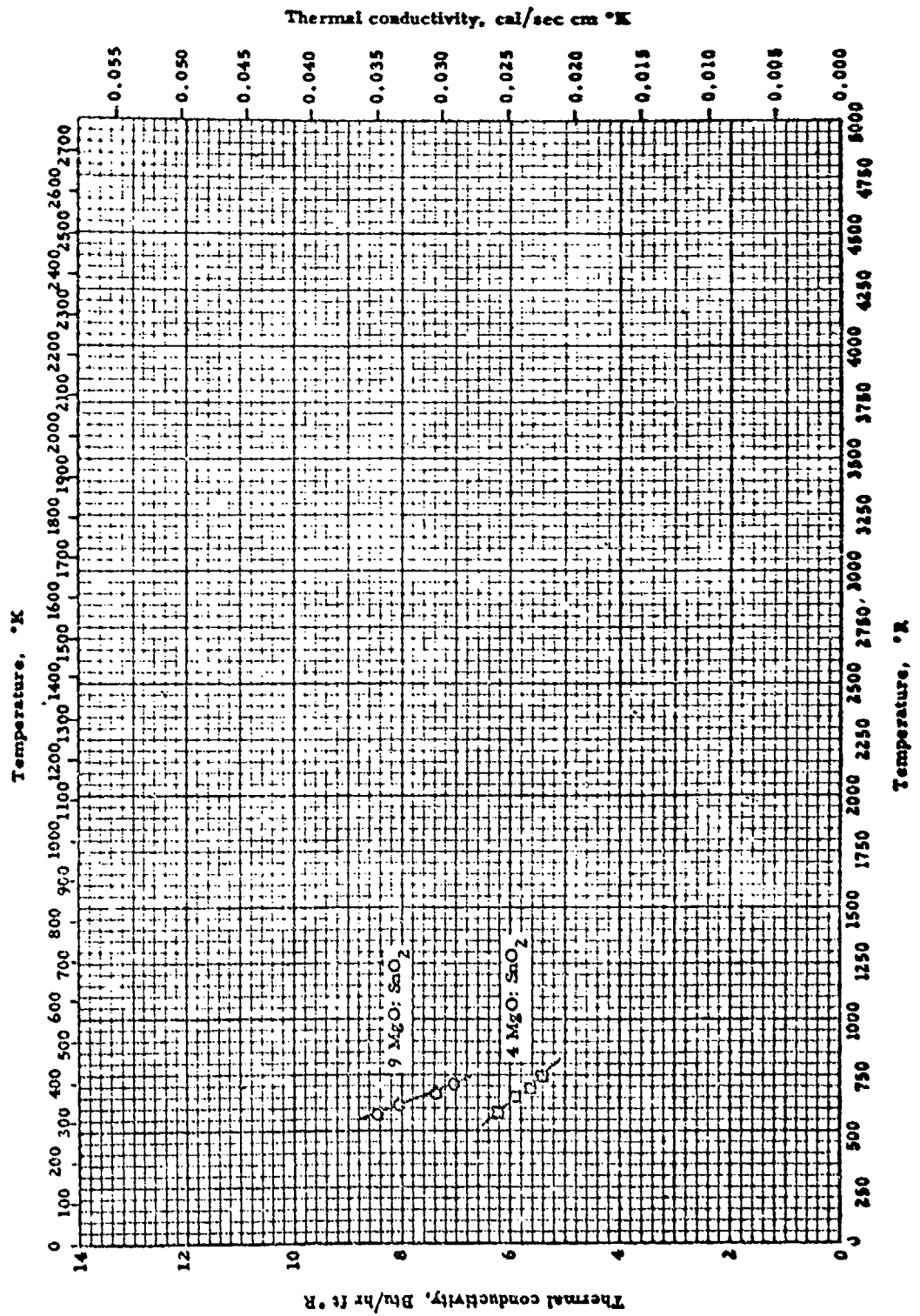


Thermal conductivity -- MAGNESIUM OXIDE + SILICON OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

$\frac{K}{cm}$	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Norton, F. H., and Kingery, W. D.	55-25	1122-2076	92.7% MgO; 7.3% SiO ₂	Comparative; rods	"Preliminary data"
○	Kingery, W. D., and Norton, F. H.	55-53	762-2112	95% MgO; 5% SiO ₂	Comparative; rods	
△	Ibid.	55-53	762-2022	85% MgO; 15% SiO ₂	Same as above	
◇	Ibid.	55-53	1122-1842	75% MgO; 25% SiO ₂	Same as above	
▽	Kingery, W. D., and Norton, F. H.	55-47	852-2112	65% MgO; 35% SiO ₂	Comparative; rods	

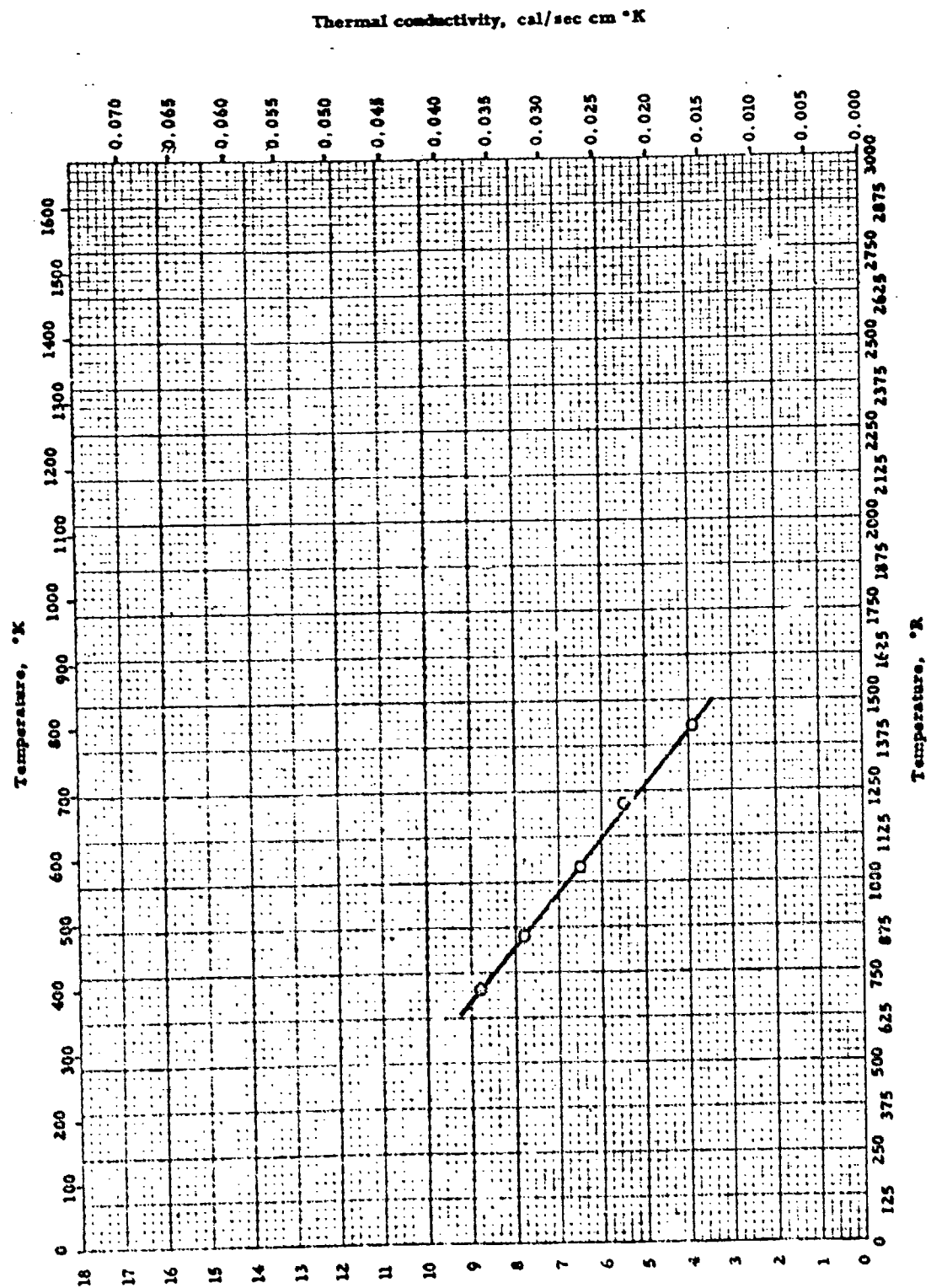


Thermal conductivity -- MAGNESIUM OXIDE + TIN OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + TIN OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-4	575-705	9 MgO : SnO ₂ : 70.7% MgO; 29.3% SnO ₂ (0.17% water absorption); $\rho =$ 240 lb _m /ft ³	Comparative	Fired 1.5 hr. at 2400°F; tested in vacuum
□	Ibid.	53-4	580-747	4 MgO : SnO ₂ : 51.7% MgO; 48.3% SnO ₂ (0.028% water absorption); $\rho =$ 261 lb _m /ft ³	Same as above	Fired 1.5 hr. at 2700°F; tested in vacuum

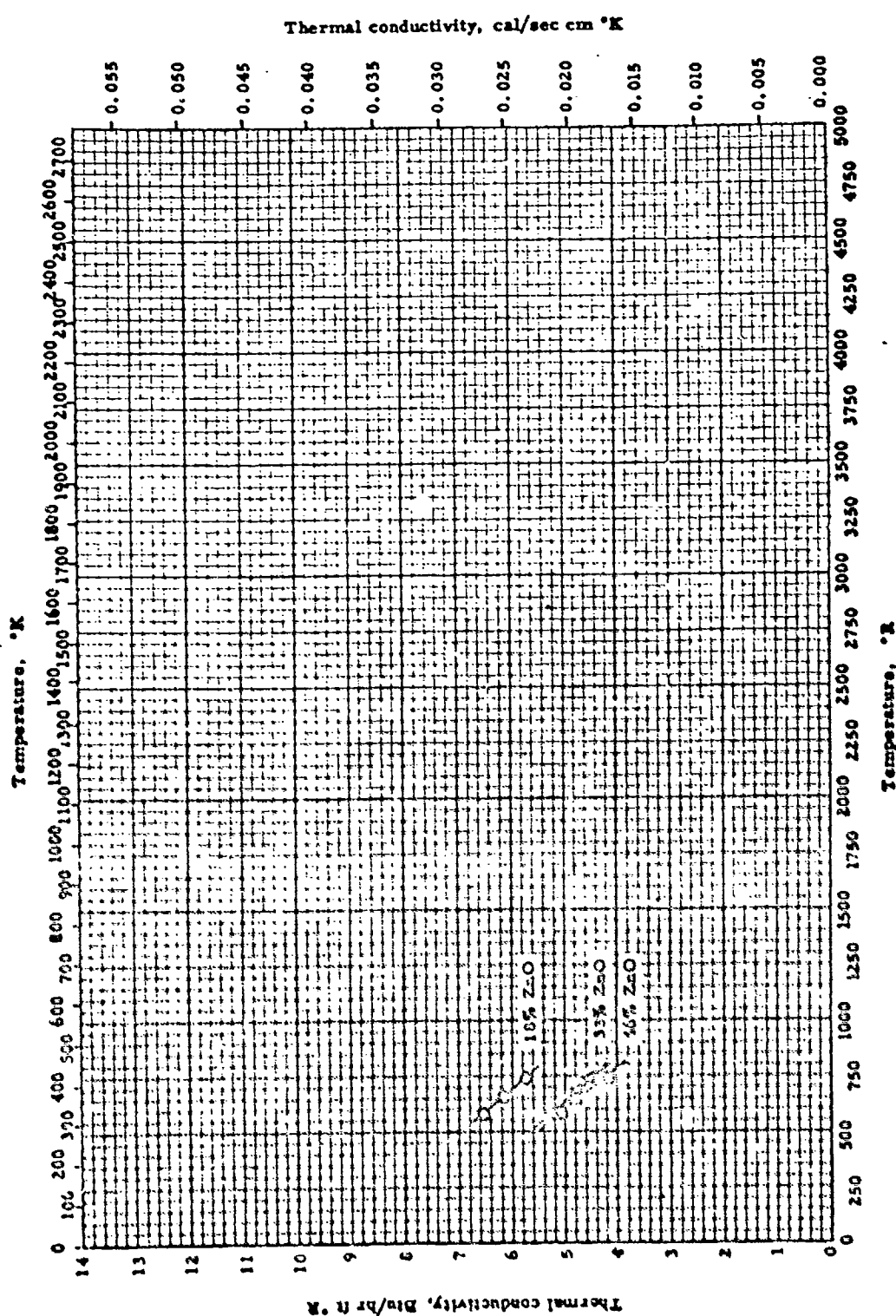


Thermal conductivity -- MAGNESIUM OXIDE + URANIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	McCright, L. R.	57-148	768-1428	53% MgO; 47% UO ₂ . p = 87% of theoretical	Two methods: a. comparative, rods b. axial heat flow in rod, calorimeter sink, guarded sample	Sintered

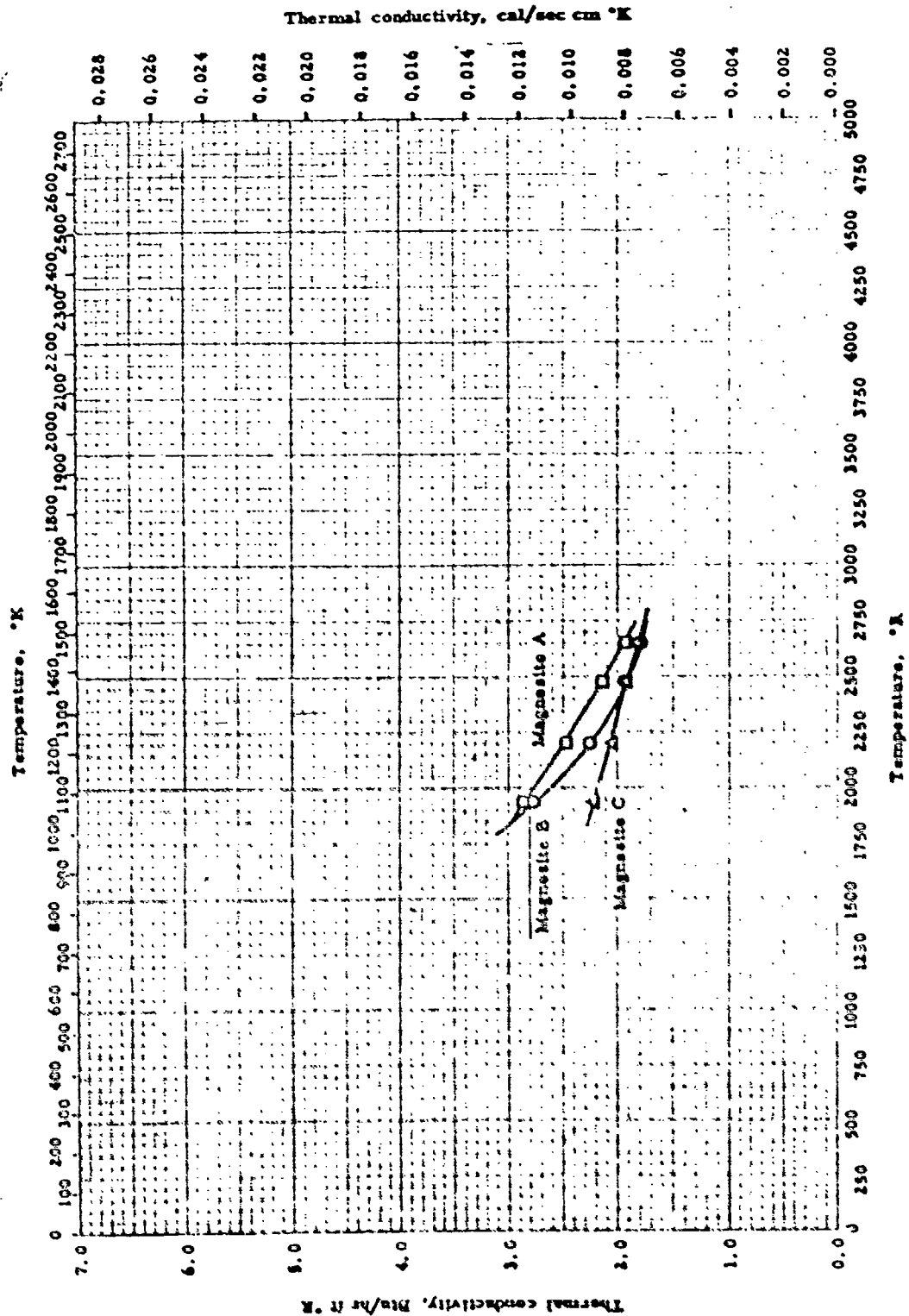


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE-ZINC OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ZINC OXIDE

REFERENCE INFORMATION

$\frac{W}{m}$	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-5	579-740	61.7% MgO; 16.1% ZnO; $\rho = 314.5$ lb _m /ft ³	Comparative; rods	9 MgO: ZnO. Fired to 2700 °F. Tested in vacuum
□	Ibid.	53-5	576-741	66.5% MgO; 33.5% ZnO; $\rho = 303.3$ lb _m /ft ³	Same as above	4 MgO: ZnO. Fired 2 hr. at 2700 °F. Tested in vacuum
△	Ibid.	53-5	574-740	53.6% MgO; 46.4% ZnO;	Same as above	7 MgO: 3 ZnO. Fired 2 hr. at 2700 °F. Tested in vacuum

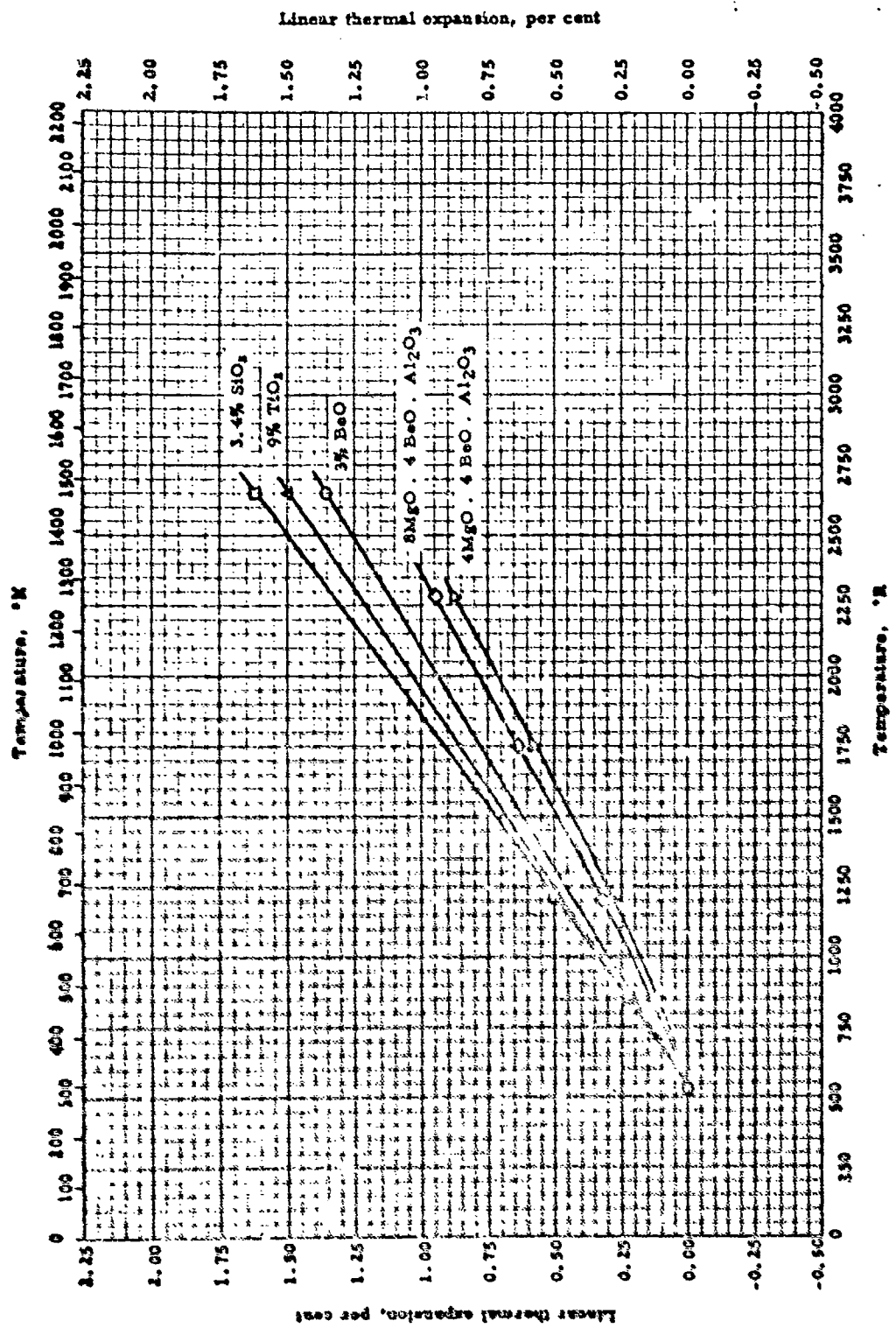


Thermal conductivity -- CALCINED MAGNESITE

THERMAL CONDUCTIVITY -- CALCINED MAGNESTE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Clumense, J.F., and Vyse, J.	57-26	1932-2632	Magnesite B: 93.10% MgO; 2.75% Fe ₂ O ₃ ; 2.16% CaO; 1.21% SiO ₂ ; 0.34% Al ₂ O ₃ ; 0.12% TiO ₂ ; 0.03% Na ₂ C; 0.01% K ₂ O; 0.12% loss on ignition. $\rho =$ 17.7 lb./in. ³ ; apparent porosity = 22.6%	Not adequately described	Auth. est. accuracy $\pm 5\%$
○	Ed4.	57-26	1932-2632	Magnesite A: 90.03% MgO; 2.40% Fe ₂ O ₃ ; 3.40% CaO; 0.65% SiO ₂ ; 0.75% Al ₂ O ₃ ; 0.16% TiO ₂ ; 0.04% Na ₂ O; 0.01% K ₂ O; 0.10% loss on ignition. $\rho = 19.2 \text{ lb./in.}^3$; apparent porosity = 14.5%	Same as above	Same as above
△	Ed4.	57-26	1932-2632	Magnesite C: 25.86% MgO; 4.99% Al ₂ O ₃ ; 3.73% Fe ₂ O ₃ ; 3.27% SiO ₂ ; 2.00% CaO; 0.13% Na ₂ O; 0.04% K ₂ O; 0.16% loss on ignition. $\rho = 18.2 \text{ lb./in.}^3$; apparent porosity = 17.3%	Same as above	Same as above



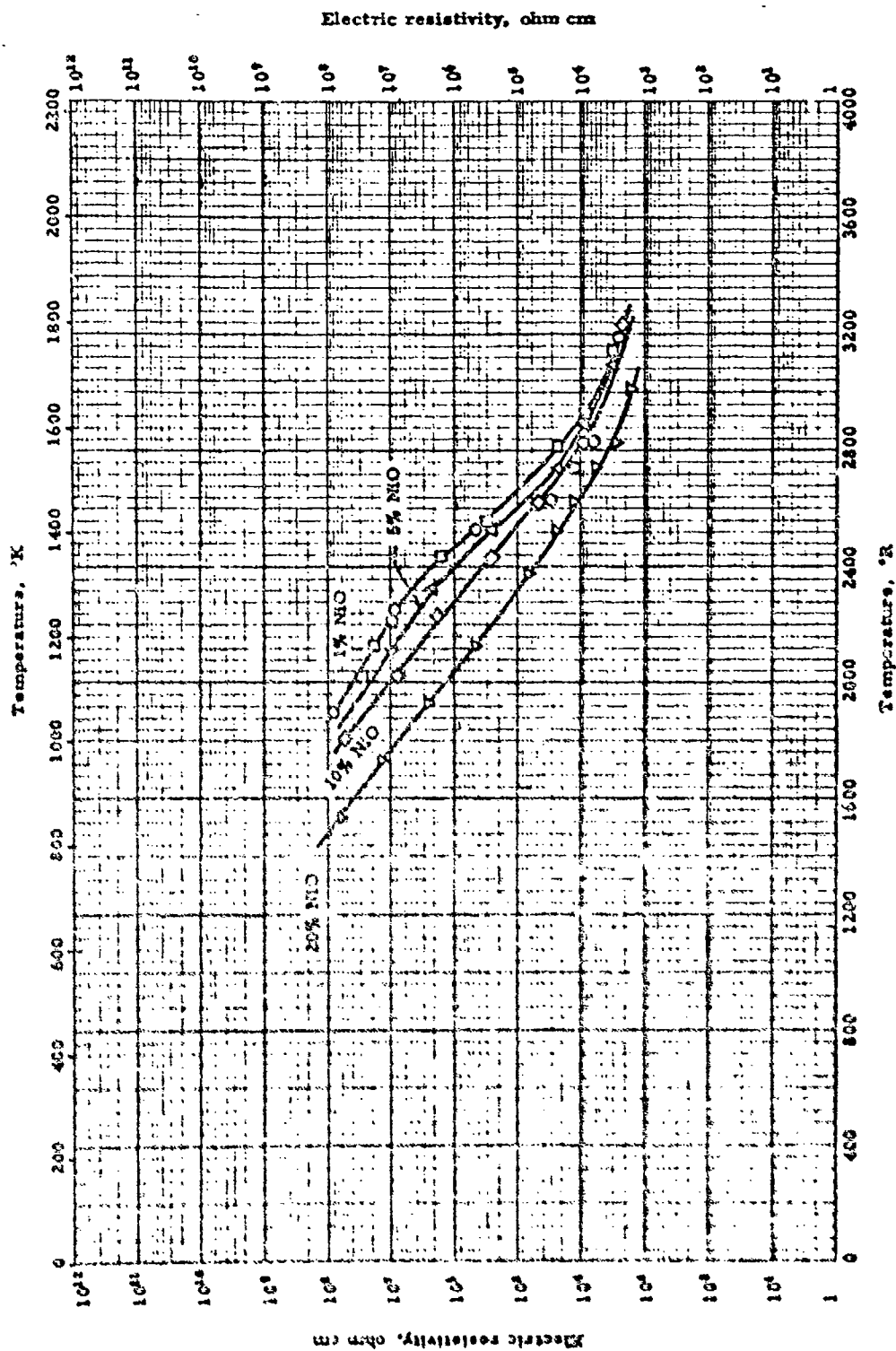
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LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE + OTHER OXIDES

LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
1	Pola, G. R., Zelinski Jr., A. W. and Gilbert, N.	46-14	528-2452	97% MgO; 3% BeO ($\approx 154 \text{ lb./ft}^3$ and 29% porosity for 2.5% BeO fired at 1450°C)	Not described here, ver sues to others	Heated at 4° C/min.
2	Idid.	46-14	528-2452	97.5% No. 93 periclase (95% MgO, 2.5% SiO ₂), 2.5% sea-water MgO. Porosity = 31%, $\rho = 155 \text{ lb./ft}^3$	Same as above	Same as above
3	Idid.	46-14	528-2452	91% MgO; 9% TiO ₂	Same as above	Same as above
4	Geller, R. F., Yavorovsky, P. J. et al.	46-4	528-2292	(MgO · 4BeO · Al ₂ O ₃). 61.49% MgO; 19.44% Al ₂ O ₃ ; 19.07% BeO prepared from 97% pure MgO, 99.7% pure BeO, 99.7% pure Al ₂ O ₃	Interferometer	
5	Idid.	46-4	528-2292	(4MgO · 4BeO · Al ₂ O ₃). 44.40% MgO; 28.08% Al ₂ O ₃ ; 27.54% BeO; raw materials same as above	Same as above	



ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Temp. °R	Material Composition	Test Method	Remarks
○	Henalar, J. R. and Henry, E. C.	53-95	1896-3192	100% MgO	Wheatstone bridge, with cathode-ray null indicator	Calcined to 1000°C in Pt, fired 10 hr. at 1500°C
□	Ibid.	53-95	2022-3192	99% MgO; 1% NiO	Same as above	Mixed c. p. MgO and c. p. NiO wet-mixed in Mullite mortar, dried calcined to 1000°C in Pt, fired 10 hr. at 1800°C
△	Ibid.	53-95	2112-3156	95% MgO; 5% NiO	Same as above	Same as above
◇	Ibid.	53-95	1806-3192	92% MgO; 10% NiO	Same as above	Same as above
▽	Ibid.	53-95	1536-3012	80% 26% NiO	Same as above	Same as above

PROPERTIES OF SILICON OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	165 lb/ft ³	2.65 g/cm ³
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	165.9	2.658
□	146.0	2.339
△	164.5	2.635
◇	146.1	2.341
▽	164.0	2.628
○	144.9	2.321
□	158.9	2.545
△	143.4	2.298
◇	162.5	2.604
▽	143.6	2.301
△	162.9	2.609
○	145.1	2.324
◇	163.3	2.615
▽	147.9	2.290
○	165 ± 4	2.65 ± 0.06

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF SILICON OXIDE

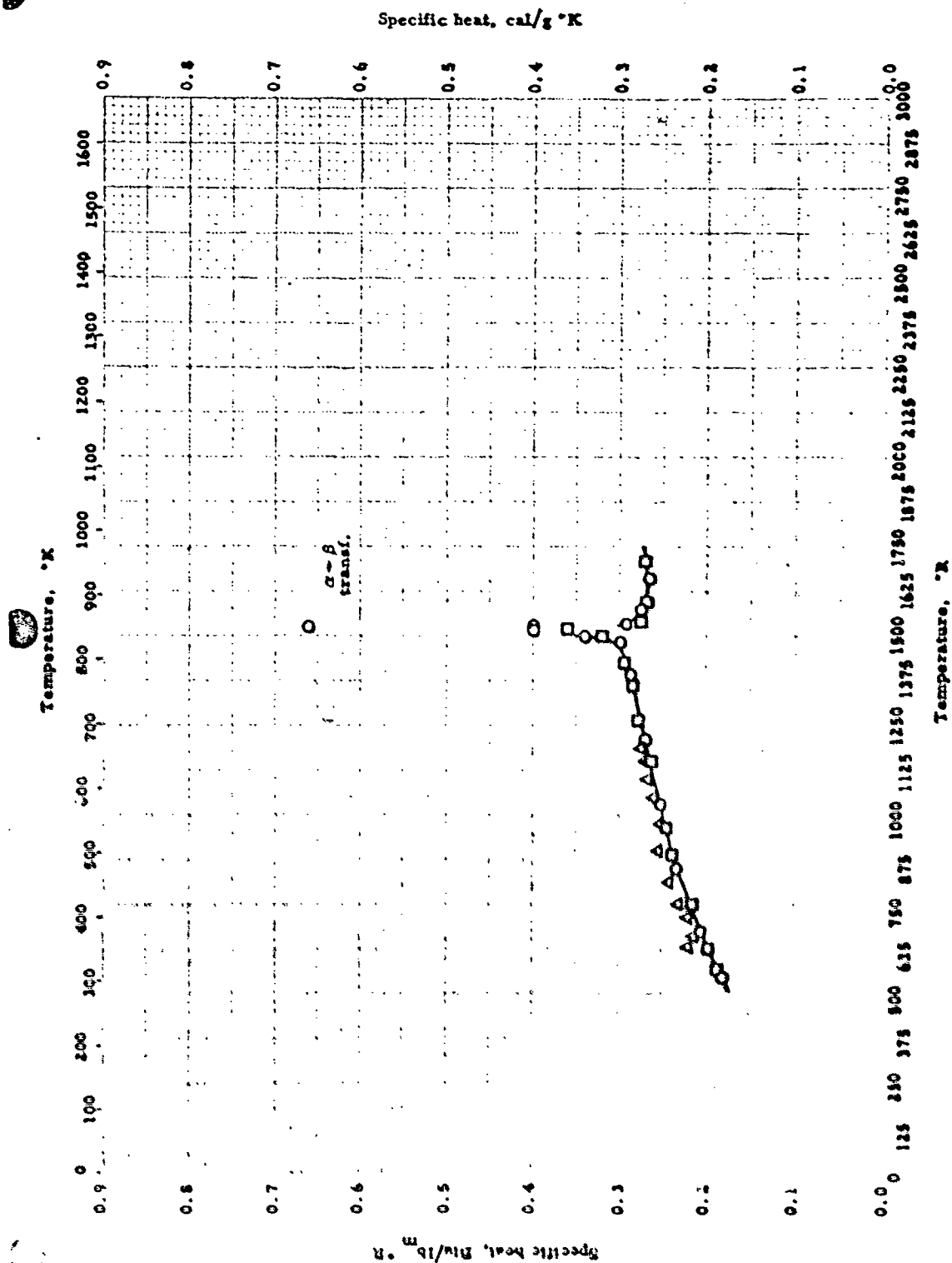
REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-141	Tokuda, T.	55-141	537	Silica rock. 95.68% SiO ₂ ; 2.87% (Al ₂ O ₃ + Fe ₂ O ₃); 0.81% CaO; 0.26% MgO	p : pycnometer	Fired 2 hr. at 1203°C in air
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 4 hr. at 1540°C in air. Auth. also reports values for conditions intermediate between Q and Q
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 2 hr. at 1201°C in reducing atmos. 0.8 atm. CO; 0.2 atm. N ₂
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 4 hr. at 1600°C in same atmos. Auth. also reports values for conditions intermediate between Δ and Q
55-141	Idid.	55-141	537	Silica rock. 97.25% SiO ₂ ; 2.17% Fe ₂ O ₃ ; 0.26% Al ₂ O ₃ ; 0.18% alkalis; 0.09% CaO; 0.03% MgO	p : same as above	Fired 3 hr. at 1311°C in air
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 4 hr. at 1550°C in air. Auth. also reports values for conditions intermediate between V and Q
55-141	Idid.	55-141	537	Silica rock. 98.35% SiO ₂ ; 0.52% Al ₂ O ₃ ; 0.43% Fe ₂ O ₃ ; 0.23% MgO; 0.05% CaO	p : same as above	Fired 3 hr. at 1400°C in air
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 4 hr. at 1330°C in air. Auth. also reports values for conditions intermediate between Q and Q
55-141	Idid.	55-141	537	Same as above	p : same as above	Fired 3 hr. at 1298°C in water vapor
55-141	Idid.	55-141	537	Silica rock. 99.72% SiO ₂ ; 0.14% Fe ₂ O ₃ ; 0.10% CaO	p : same as above	Fired 5-1/2 hr. at 1448°C in air
55-141	Idid.	55-141	537	Silica rock. Same as above	p : same as above	Fired 4 hr. at 1650°C in air. Auth. also reports values for conditions intermediate between Δ and Q

PROPERTIES OF SILICON OXIDE (cont'd)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-141	Tekada, T.	55-141	537	Silica rock. 98.35% SiO ₂ ; 0.52% Al ₂ O ₃ ; 0.43% Fe ₂ O ₃ ; 0.28% MgO; 0.05% CaO	p: pycnometer	Fired 4 hr. at 1540° C in water vapor. Auth. also reports values for conditions intermediate between O and Q
55-141	Ibid.	55-141	537	Silica rock. 99.72% SiO ₂ ; 0.14% Fe ₂ O ₃ ; 0.10% CaO	p: same as above	Fired 4 hr. at 1650° C in air. Auth. also reports values for conditions intermediate between h and O
55-141	Ibid.	55-141	537	Silica rock. 99.13% SiO ₂ ; 0.63% Fe ₂ O ₃ ; 0.11% alkali; 0.09% CaO; 0.01% ea. MgO, Al ₂ O ₃	p: same as above	Fired 3 5/60 hr. at 1240° C in air.
55-141	Ibid.	55-141	537	Same as above	p: same as above	Fired 4 hr. at 1537° C in air. Auth. also reports values for intermediate conditions
57-150	Oak Ridge National Lab.	57-150	537	Brazilian quartz	p: weight in air and in kerosene	Measured by O. Sieman, C. D. Bopp and R. L. Towns

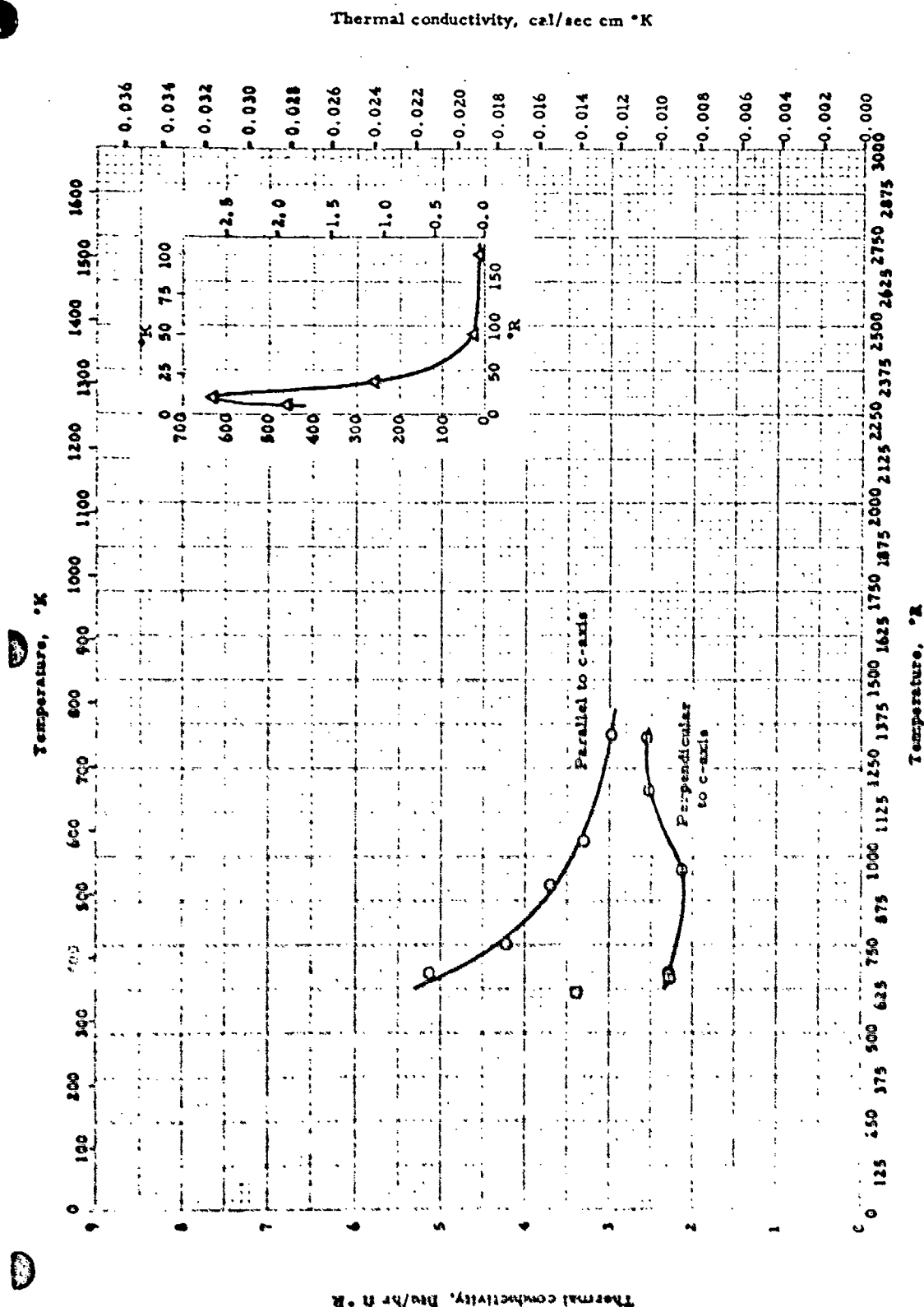


SPECIFIC HEAT -- SILICON OXIDE

SPECIFIC HEAT -- SILICON OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Kel.	Range, °R	Material Composition	Test Method	Remarks
○	Sineltukov, N. N.	53-60	546-1660	Quartz crystal	Guarded sample	
□	Moser, H.	41-13	564-1716	Quartz crystal; transparent without blemish, from Brazil	Guarded sample	
△	Skagen, H. S.	15-39	616-1212	Special high purity North Carolina crushed vein quartz, 40 to 60 mesh powder	Guarded sample	Auth. est. error at $\pm 8\%$

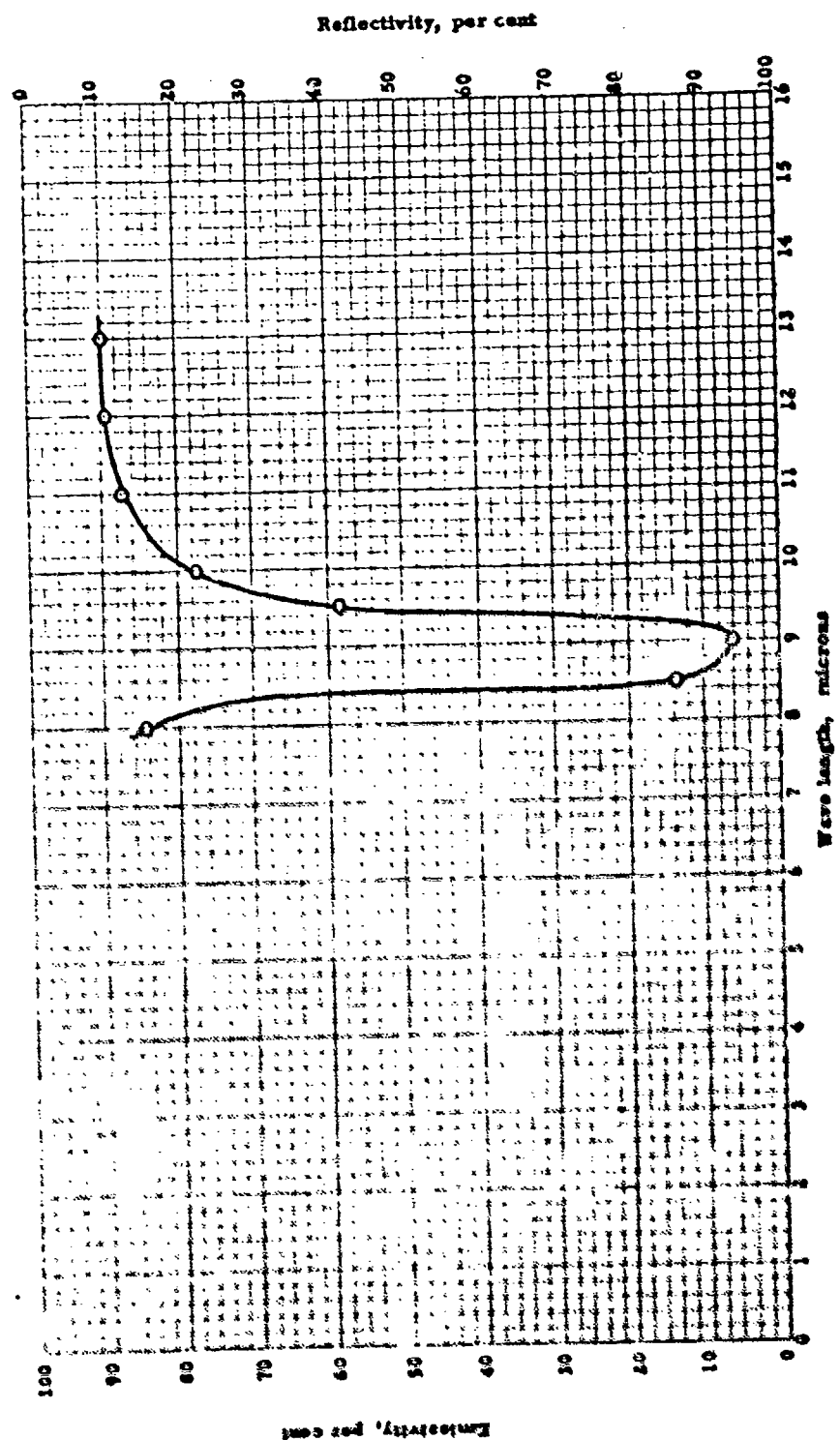


Thermal conductivity -- SILICON OXIDE

THERMAL CONDUCTIVITY -- SILICON OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Knaapp, W. J.	43-11	666-1347	Single crystal quartz	Comparative, rods. Sample 1 cm cube	○ - parallel to c axis ⊖ - perpendicular to c axis
□	Weeks, J. L. and Saffert, R. A.	51-17	618	Single crystal quartz	Comparative, rods, in vacuum with radiation shield, Armco standard	Meas. perpendicular to c axis. Auth est. accuracy ± 3%
△	Berman, R.	51-14	12-180	Single crystal quartz	Temp. distribution of sample in vacuum	

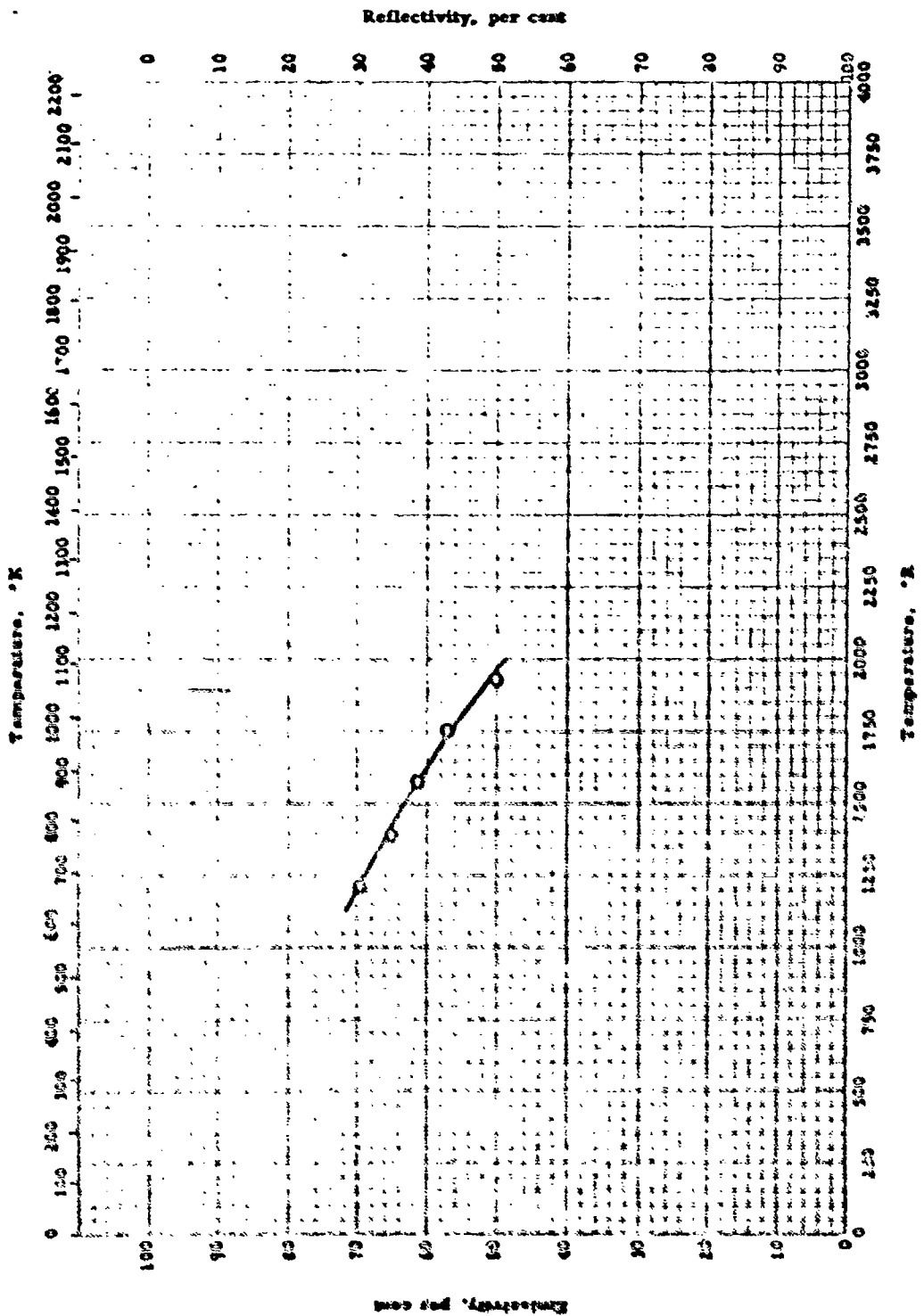


SPECTRAL EMISSIVITY -- SILICON OXIDE

SPECTRAL EMISSIVITY -- SILICON OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Fioravakaya, V. A.	53-146	Room	Low temp. crystalline quartz, cut parallel to axis	Spectral reflectivity at 13°; compared reflection from sample with Al standard mirror by thermopile	



EMISSIVITY -- SILICON OXIDE

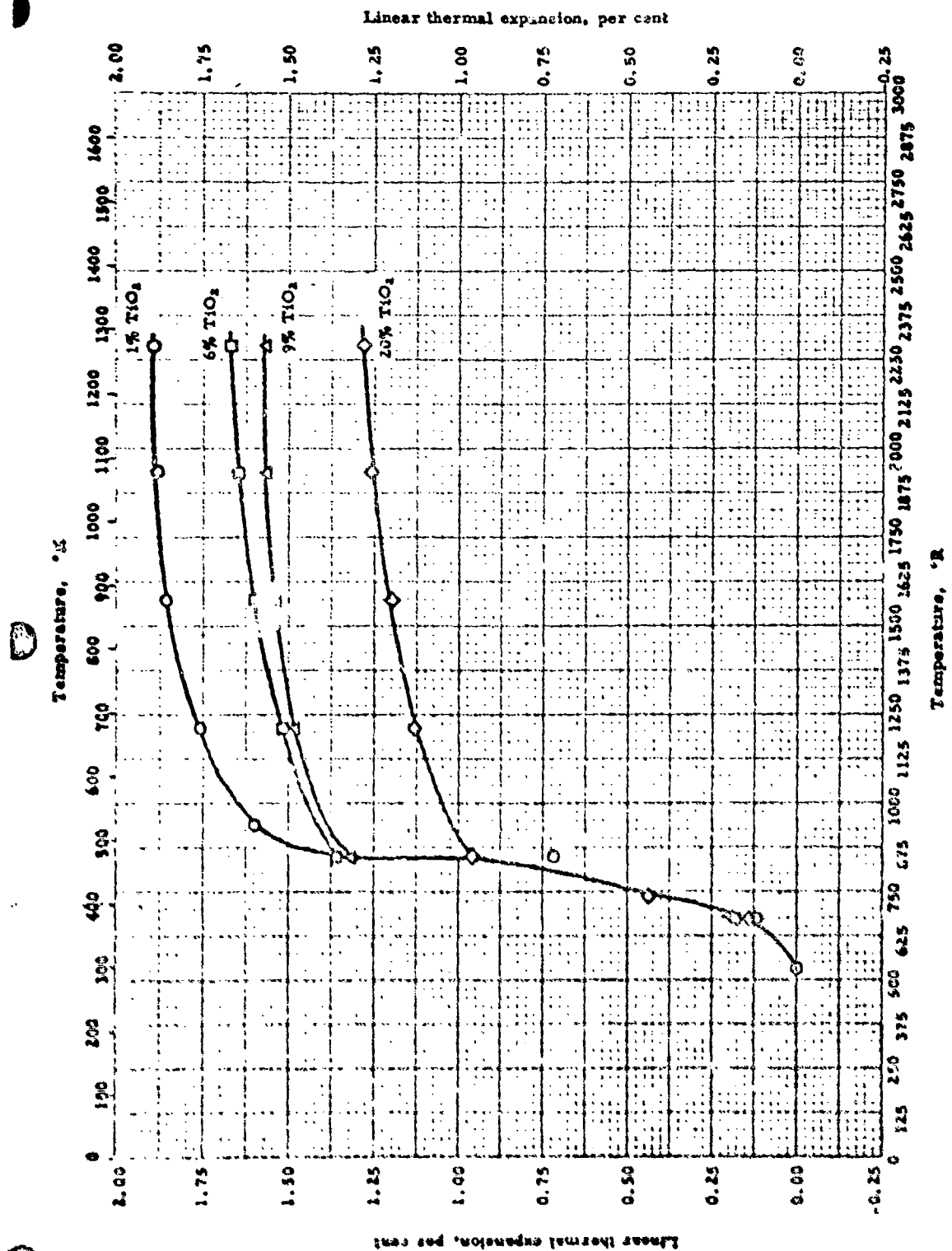
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EMISSIVITY -- SILICON OXIDE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
59-1150	Gilly, A.H., Brindley, E.A. and Waterhouse, R.B.	52-81	1212-1932	Pure silica	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	

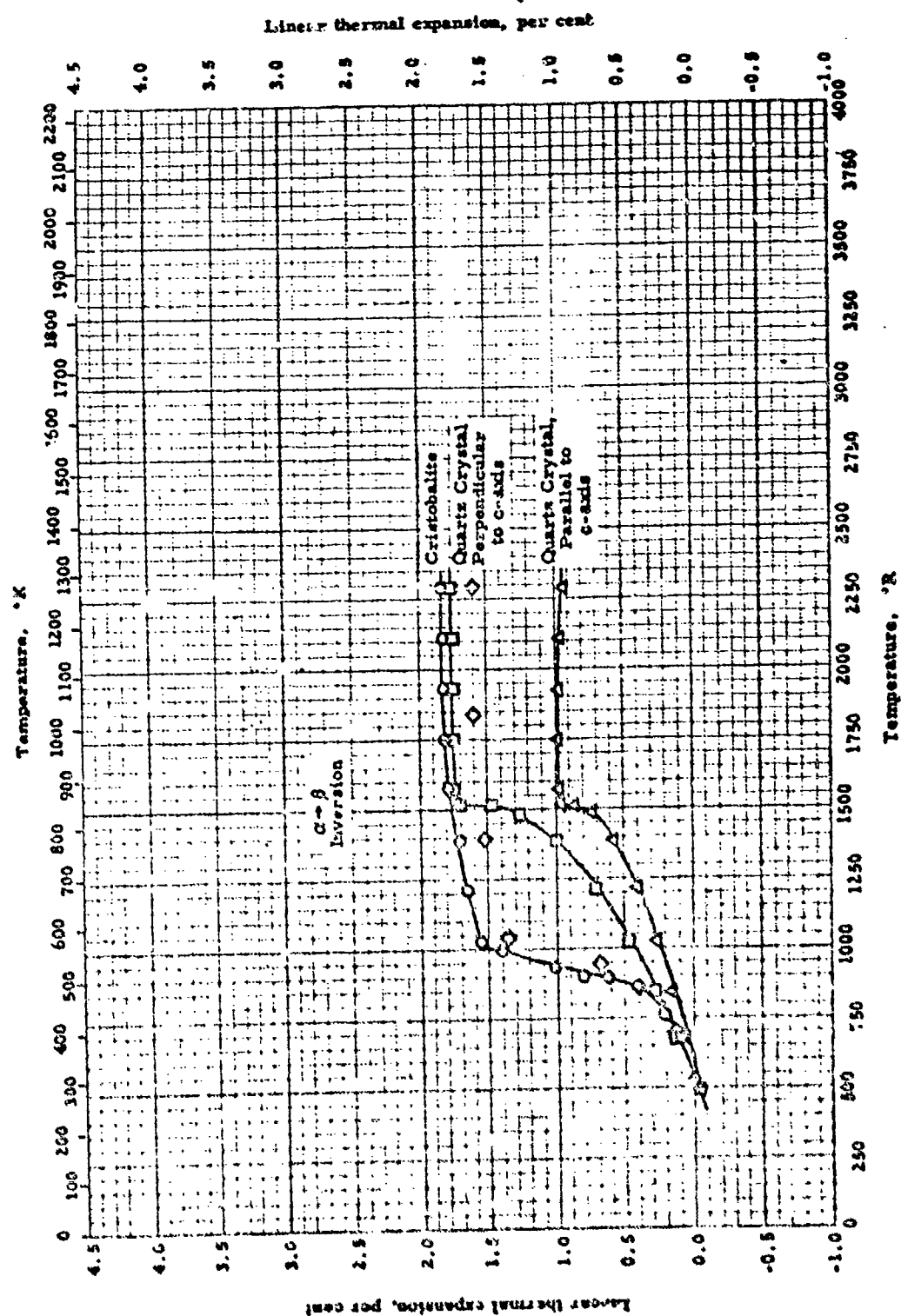


LINEAR THERMAL EXPANSION -- SILICON OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- SILICON OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Picker, R. W. and Hammal, F. A.	51-48	528-2292	99% SiO ₂ ; 1% TiO ₂	Fused silica dilatometer with dial gauge	Heated 2 hr. at 1540°C and 8 hr. at 1500°C
Dia.	51-48	528-2292	94% SiO ₂ ; 6% TiO ₂	Same as above	Same as above
Dia.	51-48	528-2292	91% SiO ₂ ; 9% TiO ₂	Same as above	Same as above
Dia.	51-48	528-2292	80% SiO ₂ ; 20% TiO ₂	Same as above	Same as above

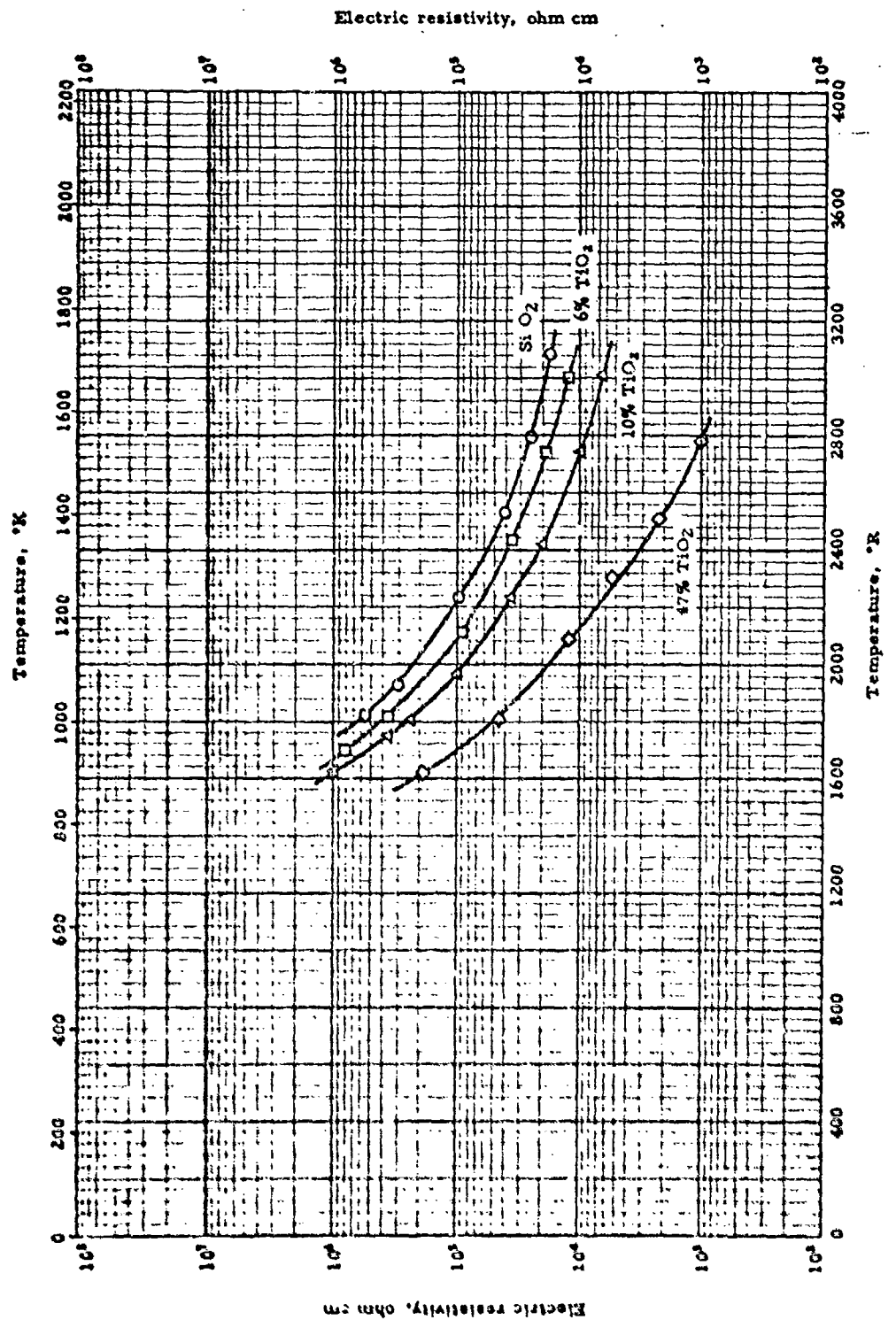


LINEAR THERMAL EXPANSION -- SILICON OXIDE

LINEAR THERMAL EXPANSION -- SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Himmel, F. A.	49-14	537-2292	Cristobalite	Fused silica dilatometer	Prepared from silica gel, calcined 1 hr. at 1500 °C; refired with 6% metaphosphate bond, pressed into bars
□	Rosenholts, J. L., and Smith, D. T.	41-8	492-2292	Quartz - clear rock crystal from Minas Geraes, Brazil; $\rho = 2.649 \text{ g/cm}^3$	Fused quartz dilatometer	Perpendicular to c-axis
△	Ibid.	41-8	492-2292	Same as above	Same as above	Parallel to c-axis
◇	Richer, R. W., and Himmel, F. A.	51-48	528-2292	Not given	Fused silica dilatometer	Heated 2 hr. at 1540 °C; 8 hr. at 1500 °C

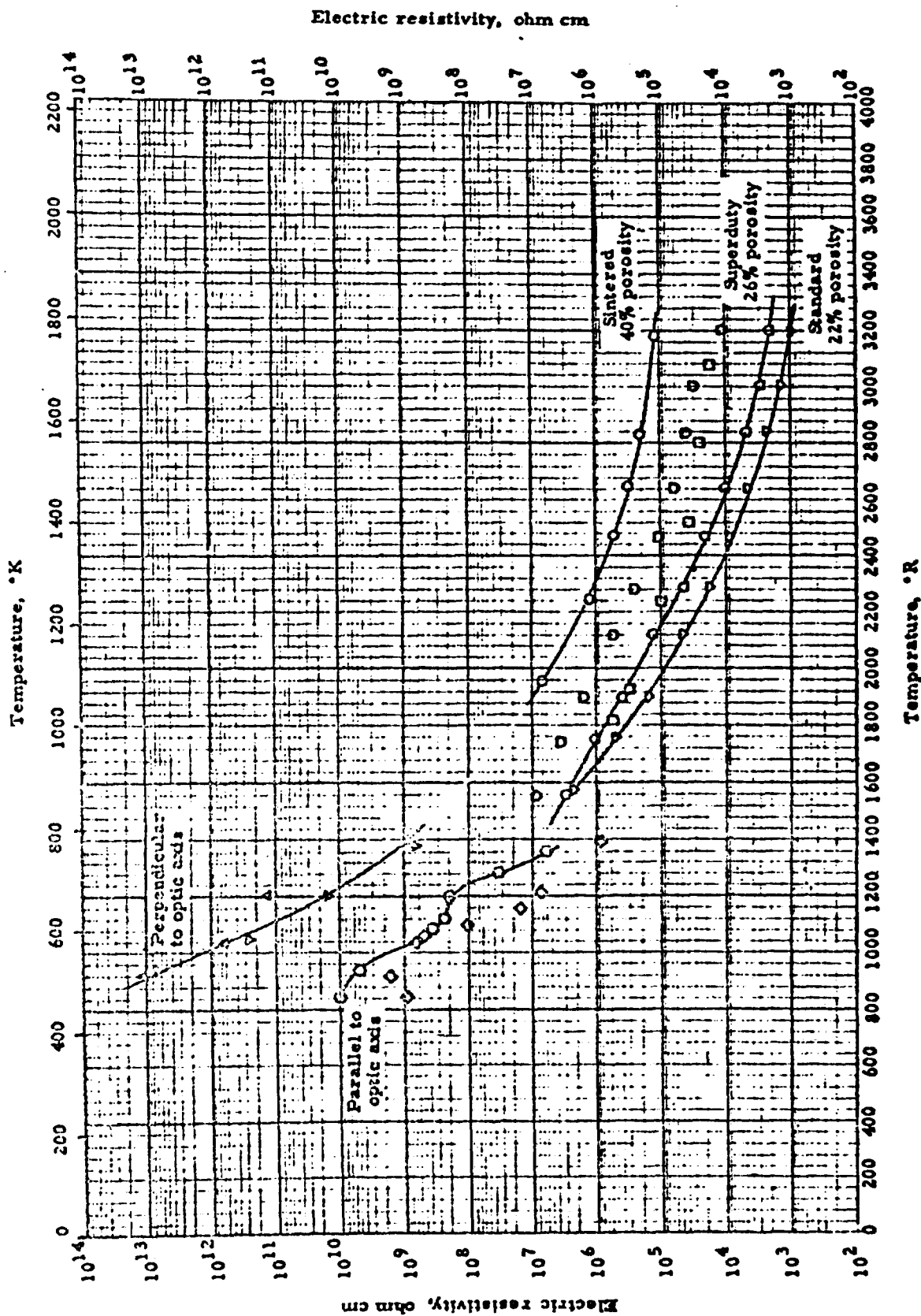


ELECTRIC RESISTIVITY -- SILICON OXIDE + TITANIUM OXIDE

ELECTRIC RESISTIVITY -- SILICON OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Hemalar, J. R. and Henry, E. C.	53-95	1824-3084	100% SiO ₂	Wheatstone bridge, with cathode-ray null indicator	Fired 24 hr. at 1450°C as described in "Study of the System SiO ₂ -TiO ₂ " thesis, Penn State College
□	Ibid.	53-95	1698-3102	94% SiO ₂ : 6% TiO ₂	Same as above	Same as above
△	Ibid.	53-95	1626-3012	90% SiO ₂ : 10% TiO ₂	Same as above	Same as above
◇	Ibid.	53-95	1626-2778	53% SiO ₂ : 47% TiO ₂	Same as above	Same as above



ELECTRIC RESISTIVITY OF SILICON OXIDE

ELECTRIC RESISTIVITY -- SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kessler, J. R. and Henry, E. C.	53-95	1568-3174	100% SiO ₂	Wheatstone bridge	40% porosity, Fired 10 hr. at 1500°C
○	Ibid.	53-95	1824-3024	Same as above	Same as above	Fired 24 hr. at 1450°C
△	National Bureau of Standards, Wash. D. C.	53-96	931-1392	Quartz crystal	Not described here, refers to others; 200 volt DC	Parallel to optic axis (?)
○	Ibid.	53-96	852-1392	Same as above	Same as above	Perpendicular to optic axis (?)
▽	Graves, S. W., Moore, D. G., et al.	56-69	947-1385	Impurities 0.01-0.1% Al; 0.001-0.01% ea. Fe, Mg, Na; 0.0001-0.001% ea. Cr, Ca, Cu	Potential drop, DC reversal every 20° C; sample temp. by Fe-Const thermocouple	Perpendicular to optic axis
○	Ibid.	56-69	857-1358	Same as above	Same as above	Parallel to optic axis
○	Chlochev, V. E. J. and Henry, E. C.	53-94	1572-3192	Super duty silica, 97% SiO ₂ ; comml. refractory	Potential drop at 965 cycles	26% porosity
○	Ibid.	53-94	1572-3192	Standard silica, 96% SiO ₂ ; comml. refractory	Same as above	22% porosity
○	Ibid.	53-94	1572-3192	92% SiO ₂ ; pyrometric cone equivalent less than standard; commercial refractory	Same as above	27% porosity

Melting Point		
	<u>°R</u>	<u>°K</u>
	3938 ± 8	2188 ± 5
	3741 ± 9	2078 ± 5

Nominal Composition

ThO₂ + Al₂O₃
 2 ThO₂ + Al₂O₃ + BeO

Symbol

○
 □

PROPERTIES OF THORIUM OXIDE + ALUMINUM OXIDE + X

PROPERTIES OF THORIUM OXIDE + ALUMINUM OXIDE + X

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
54-132	National Bureau of Standards	54-132	3930-3946	ThO ₂ + Al ₂ O ₃ 72.1% ThO ₂ ; 27.9% Al ₂ O ₃	MP: visual observation, temp. by optical pyrometer	Average of 3-5 tests, auth. est. accuracy ± 2%
54-132	Idid.	54-132	3732-3750	2ThO ₂ + Al ₂ O ₃ + BeO. 80.6% ThO ₂ ; 15.6% Al ₂ O ₃ ; 3.8% BeO	MP: same as above	Same as above

PROPERTIES OF THORIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	624 lb _m /ft ³	10 g/cm ³
Melting Point	6370 °R	3540 °K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation	1165 3870 °R Btu/lb _m	647 2150 °K cal/g

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	540	8.65
□	596	9.55
▽	625	10.01
□	606	9.70
△	609	9.75
▽	613.0	9.820
□	604	9.68
○	520	8.3
□	411	6.58
□	624	10.0
□	556 ± 6	8.9 ± 0.1
□	468	7.5
△	468	7.5
△	471 ± 23	7.55 ± 0.35
▽	537	8.6
△	499	8.0
□	606.5 ± 0.5	9.715 ± 0.015
□	613	9.82

<u>Melting Point:</u>	°R	°K
△	5492	3273
□	6378	3543
○	6287 ± 90	3493 ± 50

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
○	1161.0 337 °R	644.8 268 °K
□	1165 3870 °R	647 2150 °K
▽	984.8 5090 °R	547.1 2288 °K

PROPERTIES OF THORIUM OXIDE

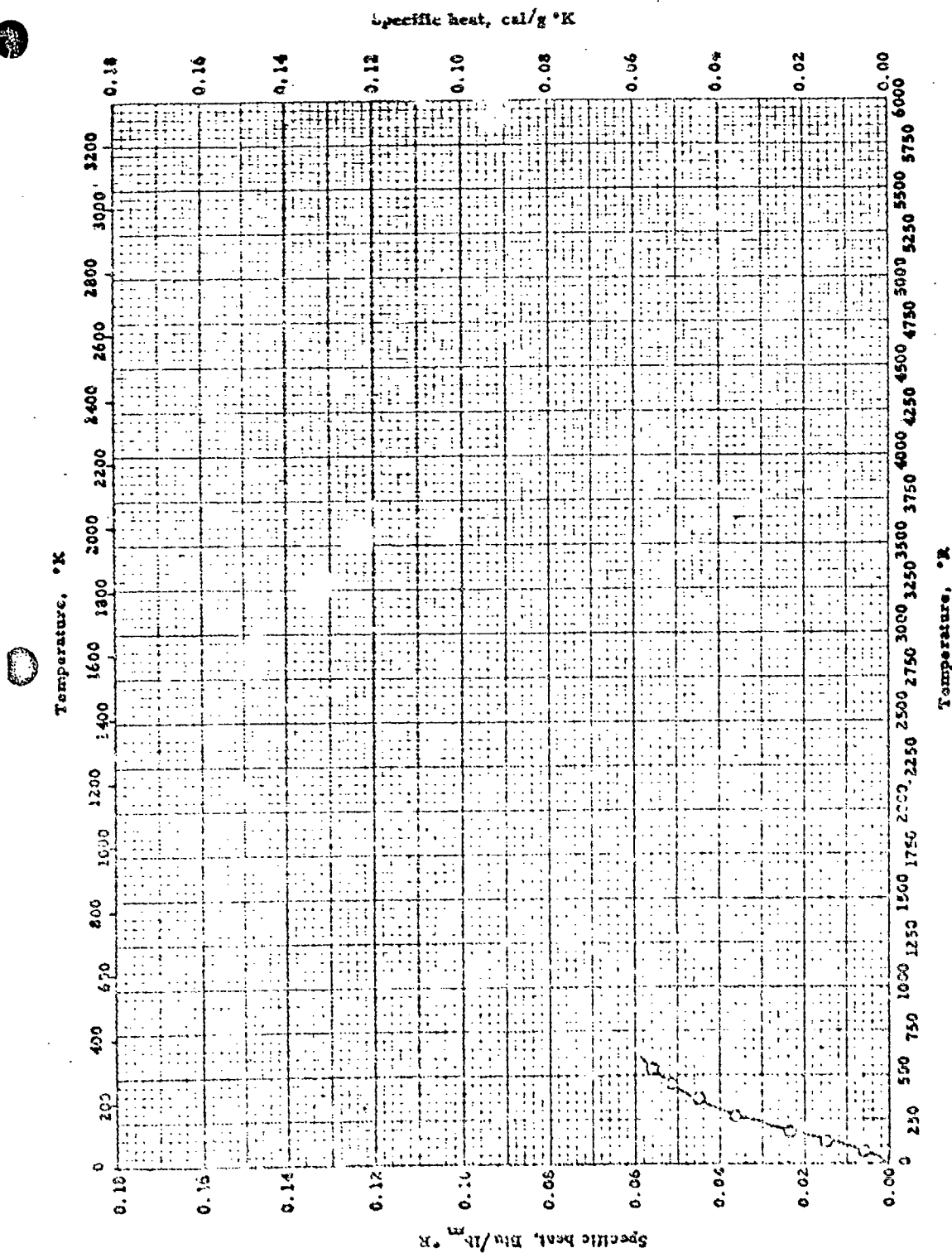
REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Tracy, M. and Johnson, H. L.	54-30	537	"Pure" ThO ₂	Δh: from vapor pressure data by Knudsen method	Vapor pressure data obtained at 4317-4817°R
Q	Engler, E.	52-16	3690-4050	99% pure ThO ₂	Δh: from vapor pressure data by Langmuir method with coated tungsten filament MP: not given BP: not given	Vapor pressure data obtained at 3690-4050°R
Δ	Tromble, F.	59-16	1892	ThO ₂	MP: not given	
Q	Lambertson, W. A. and Lindholm, J. H.	54-5	6378	ThO ₂	Δh: from vapor pressure data by Knudsen method with W cell	Short letter about preliminary results
V	Altsherman, R. J., Thorn, R. J. and Collins, P. W.	54-43	5090	ThO ₂	Δh: from vapor pressure data by Knudsen method with W cell	Pressed at 10,000 psi
Q	Lark, S. M. and Lindholm, J. H.	54-13	Room	99.9% pure ThO ₂	Δh: not given	Pressed at 5000 psi; heated 5 hr. at 1000°C; repressed at 1000,000 psi
Q	Idid.	54-18	Room	Same as above	Δh: same as above	
Q	Idid.	54-18	Room	Same as above	Δh: computed from x-ray measurements	Pressed at 10,000 psi
Q	Idid.	54-18	Room	99.5% ThO ₂ ; 0.5% CaO	Δh: not given	Pressed at 5000 psi; heated 5 hr. at 1000°C; repressed at 100,000 psi
Q	Idid.	54-18	Room	Same as above	Δh: same as above	
Δ	Idid.	54-18	Room	Same as above	Δh: computed from x-ray measurements	
Q	Lambertson, W. A. and Gussard Jr., F. M.	52-131	4377-4377	99.7% ThO ₂	Δh: visual observation after heating in constant temp. furnace. Calibrated optical pyrometer	Made from oxalate containing 40.01% Mg, Pb, Zn 40.01% ea. Ca, Cu, Bi by calcining 1 hr. at 1000°C. Heated to 1100°C in 20 min.; then fired either 2 min. at 2300°C or 10 min. at 1900°C
Q	Johansen, P. D.	50-37	Room	ThO ₂	Δh: computed from x-ray measurements of lattice	Same as above
Q	Idid.	50-37	Room	Same as above	Δh: not given	Same as above, but also pressed at 52,000 psi
Q	Idid.	50-37	Room	Same as above	Δh: same as above	

PROPERTIES OF THORIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Ref.	Investigator	Temp., °R	Material Composition	Test Method	Remarks
1	W. L. Lenz, M. D. and Parker, H. E.	Room	TiO ₂	p: computed from x-ray mea- surements of lattice	Molded at 10,000 psi
2	Id.	Room	Same as above	p: weight in air and in Hg	Same as above, fused 1 hr. at 1800°C from 0-5µ particles
3	Id.	Room	Same as above	p: same as above	Same as above, but particles are 10-15µ
4	Id.	Room	Same as above	p: same as above	Same as above, but particles are 30-40µ
5	Id.	Room	Same as above	p: same as above	Same as above, but mixtures of particles
6	Id.	Room	1% TiO ₂	p: same as above	Same as above, but particles are 10-15µ
7	Id.	Room	1% Fe ₂ O ₃	p: same as above	Same as above
8	Id.	Room	0.5% CaO	p: same as above	
9	Id.	Room	Same as above	p: computed from x-ray mea- surements of lattice	

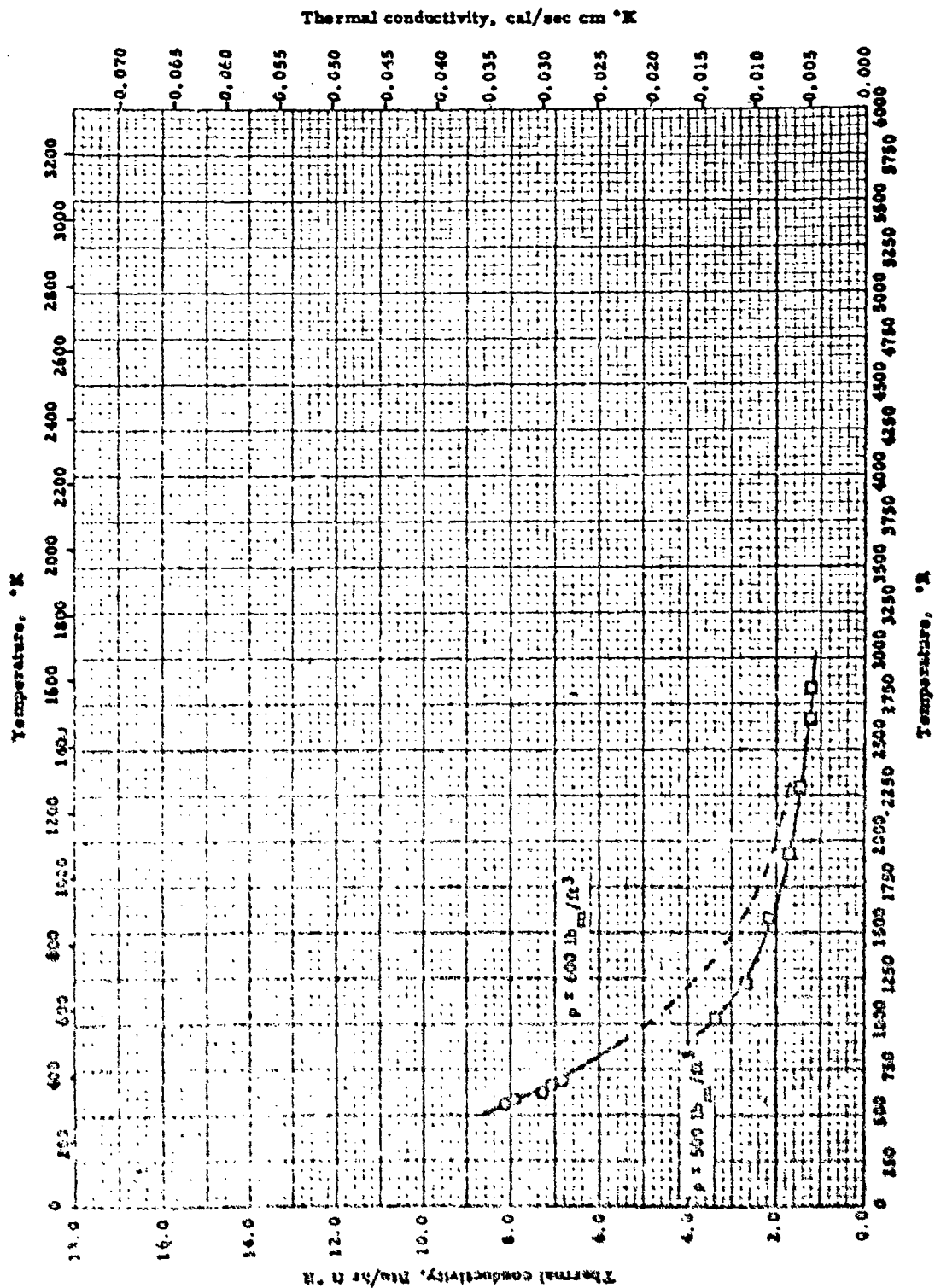


SPECIFIC HEAT -- THORIUM OXIDE

SPECIFIC HEAT -- THORIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O Ochsman, D. W., and Westrum, Jr. E. F.	53-55	18-540	Theoria, ThO ₂ 0.015% max. rare earths; 0.005% ea. Al, Si; 0.004% La; <0.005% others	Guarded sample	

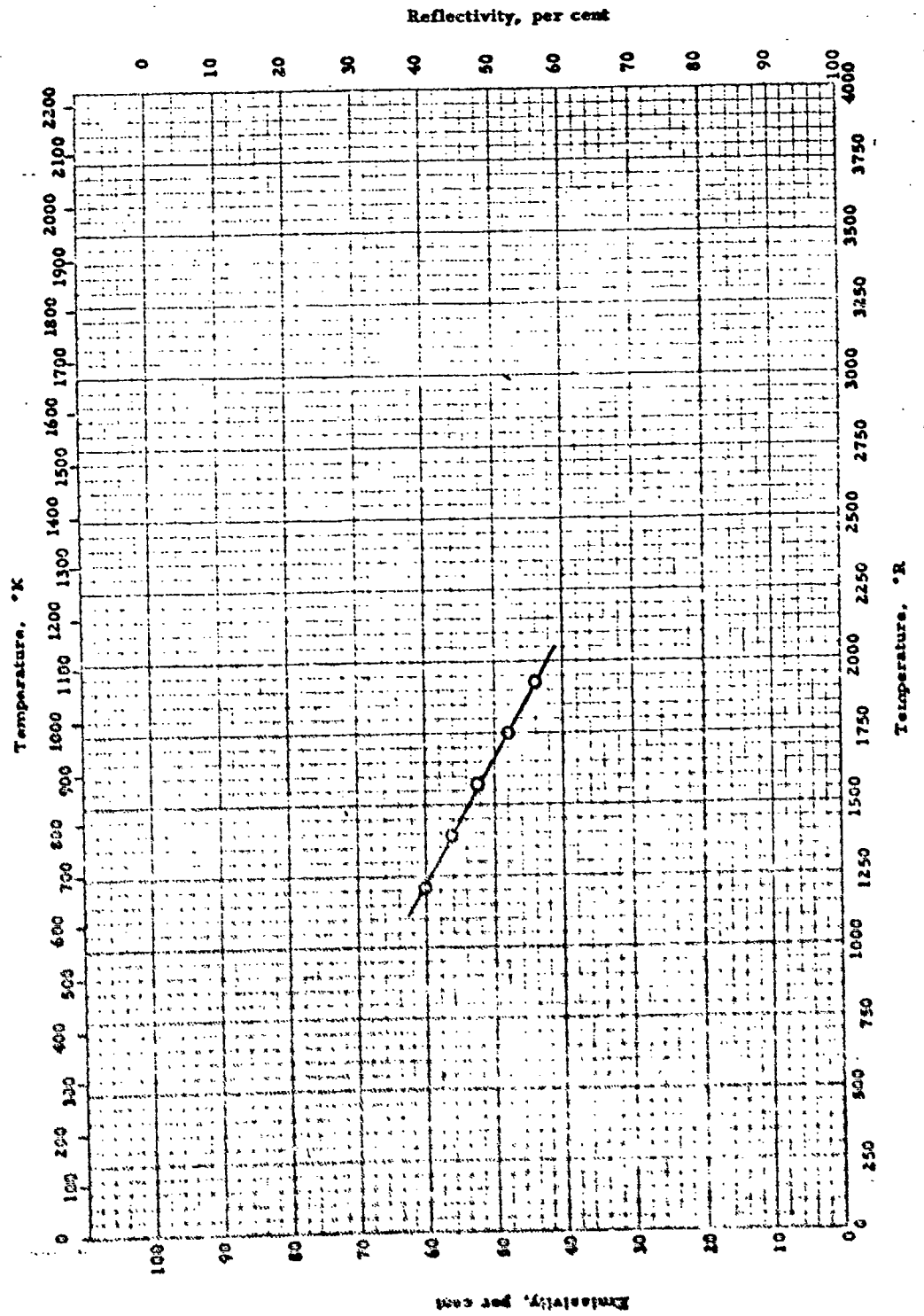


Thermal conductivity -- THORIUM OXIDE

THERMAL CONDUCTIVITY -- THORIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-3	531-682	Spectroscopically pure; $\rho = 999 \text{ lb/ft}^3$	Comparative; rods (Cu standard)	Hot pressed at 1790 - 1820°C (Tested in vacuum)
□	Adams, Milton	54-5	1222-2232	$\rho = 504 \text{ lb/ft}^3$; total porosity = 16.7%	Prolate spheroid shape loose	Slip cast from suspension of finely ground material



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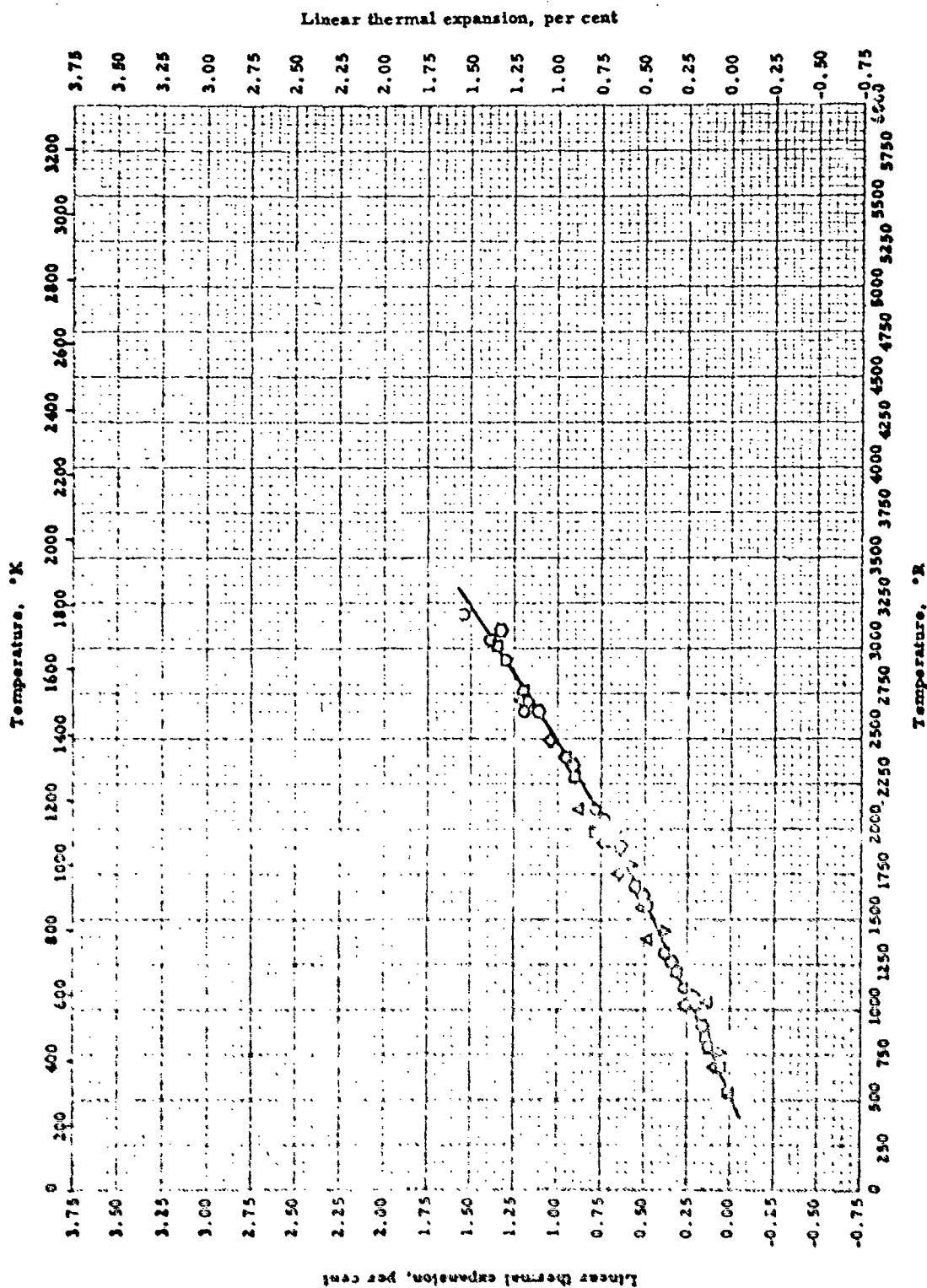
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EMISSION -- THORIUM OXIDE

EMISSIONS -- THORIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Baily, A. H. Druides, E. A. and Waterhouse, E. B.	52-81	1212-1932	"Pure"	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh ther- mocouple	



LINEAR THERMAL EXPANSION - THORIUM OXIDE

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LINEAR THERMAL EXPANSION -- THORIUM OXIDE

REFERENCE INFORMATION

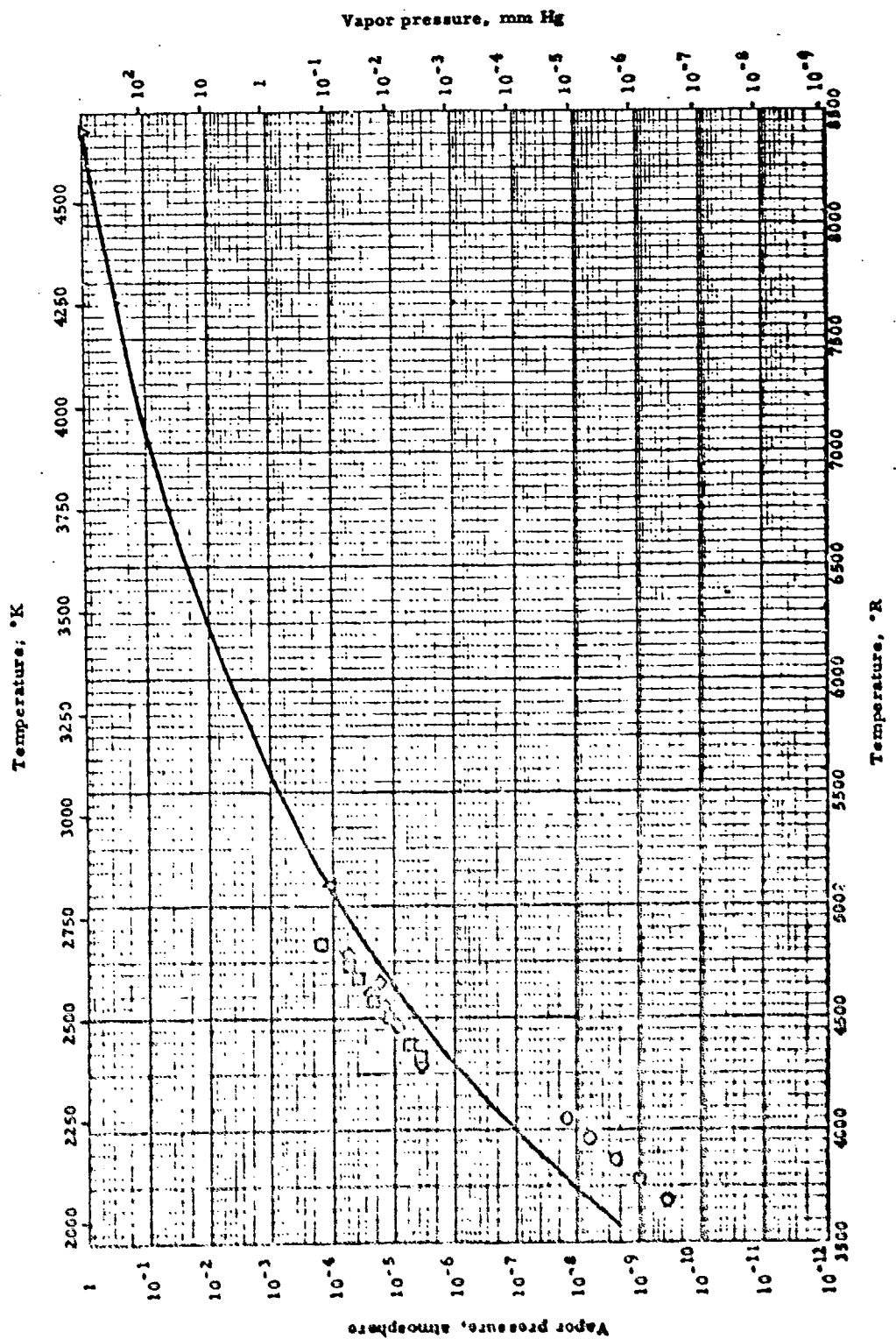
Ref.	Investigator	Range, °R.	Material Composition	Test Method	Remarks
56-7	Whittemore, O. J. and Ault, N. N.	1032-3192	Fine fused grain ThO ₂	Telemicroscopes sighting on sample	Data to 800°C checked with interferometer
56-18	Long, S. M. and Kaulsen, F. P.	546-3012	ThO ₂ 0.5% CaO	Dilatometer	Fired at 1800°C
57-22	Curtis, C. E. and Johnston, J. R.	672-2706	ThO ₂ 1% CaO	Not given	Same as above
57-22	Ibid.	672-2706	"Pure"; 75% theoretical density	Same as above	Auth. est. accuracy ± 0.2%
57-21	Minner, B. J.	536-1931	0.1-0.5% ea. Si, Mg; 0.01-0.05% ea. Fe, B, Al; 0.001-0.005% ea. Sc, Cu; 0.0001-0.0005% Be	X-ray diffraction	
57-93	Somaya, S., Yamauchi, T. and Suzuki, H.	528-3102	"Pure" ThO ₂	Dilatometer	Dry mixed, pressed at 1000 kg/cm ² ; fired to 1700°C in 5-1/2 hr; held 1 hr; cooled overnight. Plotted data are average of auth.'s heating and cooling curves
55-58	Mauer, F. A. and Dolz, L. H.	492-3019	ThO ₂ + 0.001-0.01% Al, 0.0001-0.001% ea. Ag, Ca, Cu, Mg	X-ray diffraction	Dry pressed (no binder) at 3000 psi, pressed 1 hr. at 1800°C under 30,000 psi in oxidizing atmo.
55-147	National Bureau of Standards	546-1932	99.5% ThO ₂ ; 0.5% CaO, p=606-607 lb m/ft ³	Interferometer	Pressed sample heated, pressed 1 hr. at 1800°C, under 30,000 psi
55-144	Eurdick, M. D. and Parker, H. S.	546-3012	99.5% ThO ₂ ; 0.5% CaO	Dilatometer	Same as above
55-144	Ibid.	546-1932	Same as above	Interferometer	

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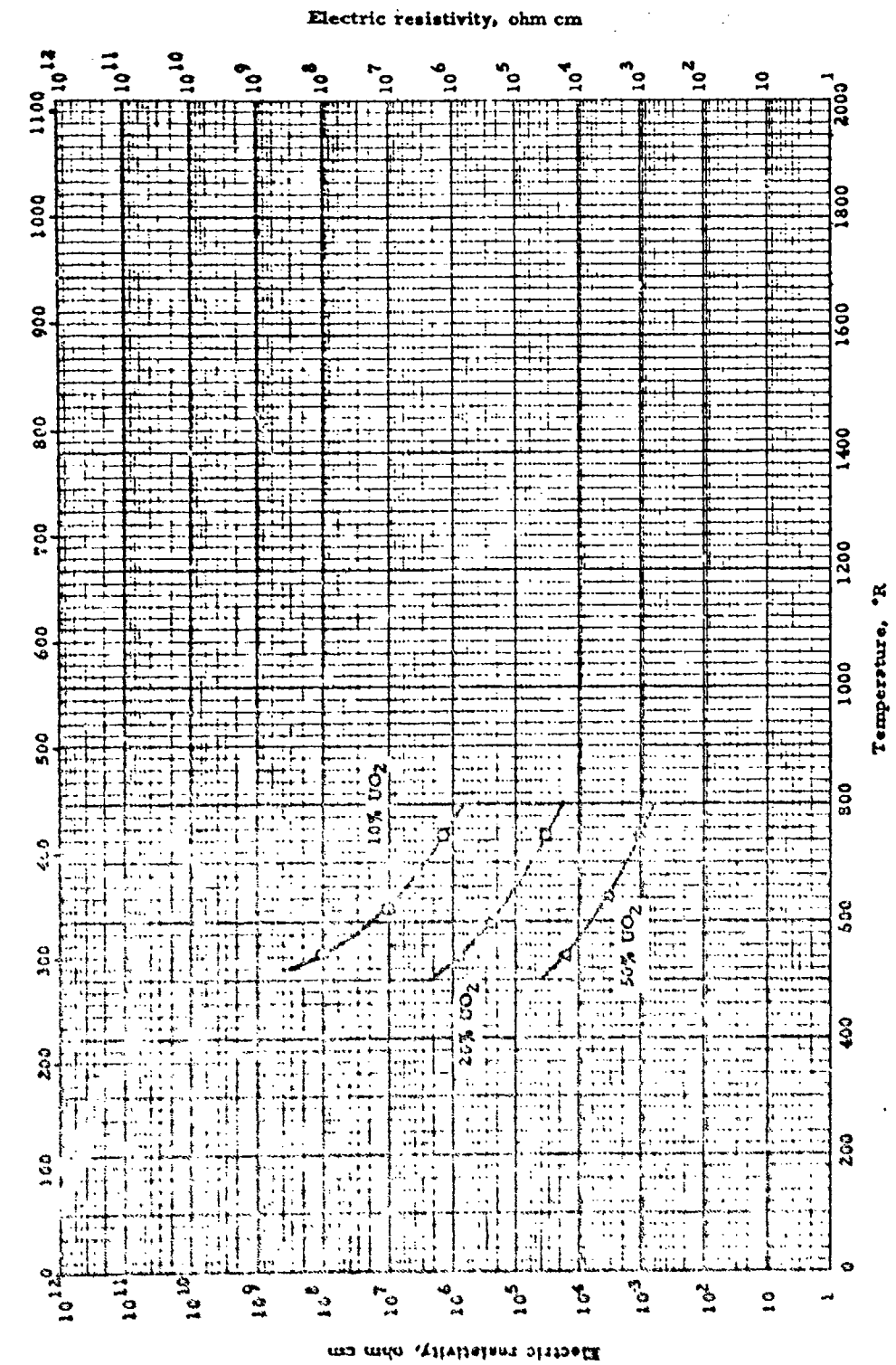


VAPOR PRESSURE -- THORIUM OXIDE

VAPOR PRESSURE -- THORIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
52-15	Shapiro, E.	52-15	3690-4050	99% pure ThO ₂	Langmuir weight loss method	W wire coated with ThO ₂
54-30 also 54-138	Hoch, N. and Johnston, H. L.	4317-4817	4317-4817	"Pure" ThO ₂	Knudsen effusion cell	Ta cell degassed for 2 hr. before each run. Corrected for evaporation of cell (ca 10%)
56-43	Ackermann, R. J., Thorn, R. J. and Gilles, P. W.	5091	5091	ThO ₂	Knudsen effusion cell	W cell
49-16	Trombe, F.	6412	6412	ThO ₂	Not given	
54-39	Hoch, M. and Johnston, H. L.	4300-4790	4300-4790	ThO ₂	Knudsen effusion cell	Corrected for evaporation of Ta cell material and for thermal expansion of orifice. Authors suspect major error in temp. measurement leading to high values for p

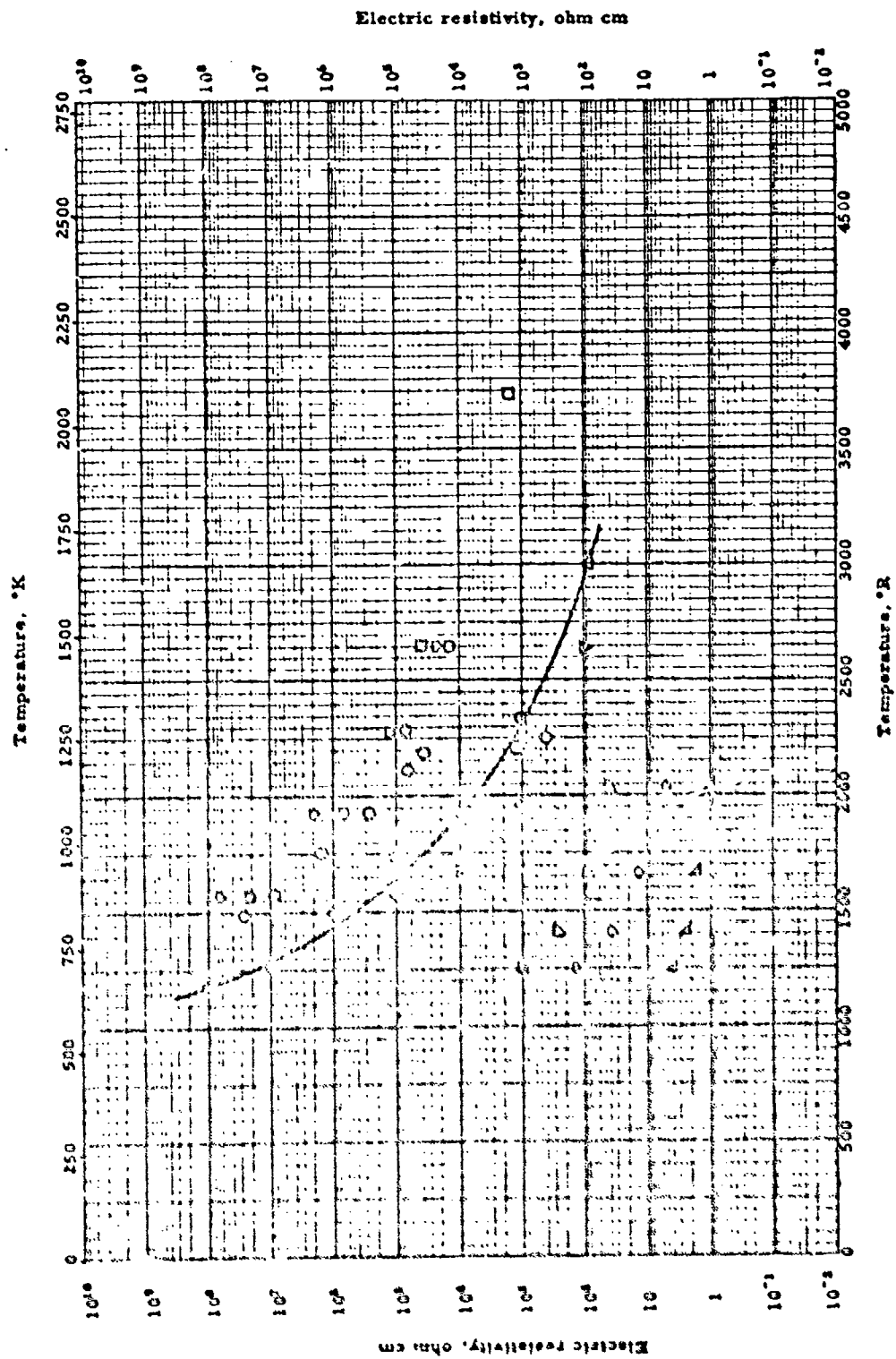


ELECTRIC RESISTIVITY -- THORIUM OXIDE + URANIUM OXIDE

ELECTRIC RESISTIVITY -- THORIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
C. Gruen, D. M.	54-143	545-750	99% ThO ₂ ; 1% UO ₂	Potential drop; sample temp. by Chromel-Alumel thermocouple	Mixed from elements with <0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H ₂
C. Ibid.	54-143	545-750	80% ThO ₂ ; 20% UO ₂	Same as above	Same as above
A. Ibid.	54-143	545-750	50% ThO ₂ ; 50% UO ₂	Same as above	Same as above

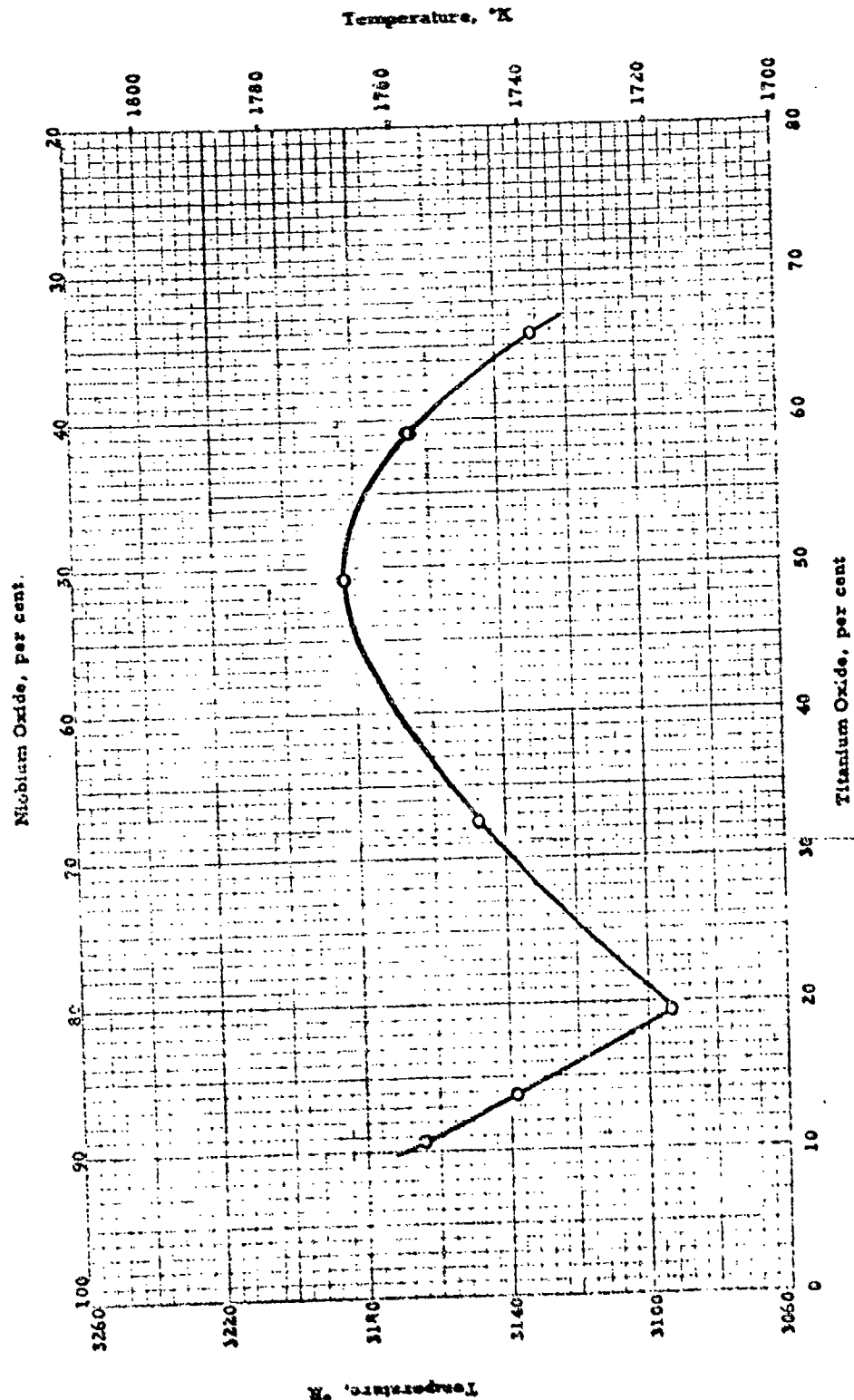


ELECTRIC RESISTIVITY -- THONIUM OXIDE

ELECTRIC RESISTIVITY -- THORIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Regener, H.	40-20	1491-2193	TbO ₂	Potential drop. Voltage by electrometer. Sample temp. by Pt-Pt Rh thermocouple	1 cm. cube samples, platinized end faces. Auth. est. accuracy only order of magnitude
Trombe, F.	49-16	2652-3732	TbO ₂	Not given	H ₂ and He atmosphere
Danforth, W. E.	54-141	1185-2250	TbO ₂ . 0.01% Al. La; traces of Cr, Cu, Si, Be, Ti, Ce, Y, and Zr	Potential drop, using a pulse charge. Checked against a Wheatstone bridge	O ₂ atmosphere
Ibid.	54-141	1500-2250	Same as above	Same as above	Meas. in O ₂ at 760 mm Hg
Ibid.	54-141	1682-2647	Same as above	Same as above	Meas. in O ₂ at 0.37 mm Hg
Ibid.	54-141	1875-2250	Same as above	Same as above	Meas. in O ₂ at 0.00002 mm Hg
Ibid.	54-141	1731-2336	Same as above	Same as above	Arc fused, cut into parallelepipeds
Danforth, W. E.	56-159	1268-3001	TbO ₂	Pulse charge, read on scope	Meas. under 10 ⁻⁶ mm Hg. Resistance R by equation: $\frac{1}{R} = \frac{V}{\frac{A}{L} \cdot \frac{B}{T}}$
Fox, M.	42-14	1572-2652	TbO ₂ . Porosity = 24%. $\rho = 487 \text{ lb}_m/\text{ft}^3$	Not given	Very pure, no caria. Pressed at 9,000 kg/cm ² , calcined at 2100°C $r = A \cdot \left(\frac{B}{T}\right)^n$ where A, B = const., n = absolute temp. Meas. in air atmos.
Ibid.	42-14	1572-2652	Same as above	Same as above	Same as above, except meas. in vacuum. Author also reports measurements in other atm.
Danforth, W. E. and Morgan, F. H.	50-65	1250-2041	TbO ₂ . $\rho = 437 \text{ lb}_m/\text{ft}^3$	Potential drop	r varies as current density J. ² Meas. in vacuum. J = 7.6 amp/cm ²
Ibid.	50-65	1250-2041	Same as above	Same as above	Same as above, except J = 0.76 amp/cm ²
Ibid.	50-65	1250-2041	Same as above	Same as above	Same as above, except J = 0.076 amp/cm ²



MELTING POINT -- TITANIUM OXIDE + NIOBIUM OXIDE

REFERENCE INFORMATION

C	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Farbim, E. A. and Harman, C. G.	52-51	3093-3183	59.65 - 65.79% TiO ₂ ; 40.95 - 34.21% Nb ₂ O ₅	MP; not given	Prepared from 99.5% TiO ₂ + 99.9% Nb ₂ O ₅ ; sintered

PROPERTIES OF TITANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	250 lb _m /ft ³	4.0 g/cm ³
Melting Point.	3800°R *	2110°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	3920 _{536°R} Btu/lb _m **	2175 _{298°K} cal/g **

* Value for TiO₂, rutile

** Value for TiO₂

REPORTED VALUES

Density:	lb _m /ft ³	g/cm ³
○	243.7 ± 0.1	3.904 ± 0.002
□	259.1 ± 0.1	4.150 ± 0.002
△	228	3.66
◇	244	3.92
▽	239	3.83
○	228	3.66
◇	240	3.85
□	243	3.90
□	161	2.59
□	164	2.64
△	208	3.34
△	157	2.52
▽	158	2.54
△	250.3 ± 0.6	4.01 ± 0.01

Melting Point:	°R	°K
△	3383	1993
○	3404 ± 16	2113 ± 10

Heat of Fusion:	Btu/lb _m	cal/g
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Heat of Vaporization:	Btu/lb _m	cal/g
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Heat of Sublimation:	Btu/lb _m	cal/g
▽	3129 _{0°R} ± 11	1738 _{0°K} ± 6
○	3790 _{0°R} ± 15	2106 _{0°K} ± 8
□	3920 _{536°R} ± 140	2175 _{298°K} ± 78
▽	3190 _{536°R} ± 110	1830 _{298°K} ± 60

PROPERTIES OF TITANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Lieta, J.	56-52	Room	TiO ₂ ; anatase; x-rays showed only anatase lines	p; powdered sample in pycnometer with kerosene	Synthetically prepared from doubly distilled clear and colorless TiCl ₄ , practically free of Fe, precipitated with ammonia, washed, heated 4 hr. at 565°C
Lieta, J.	56-52	Room	TiO ₂ ; rutile; x-rays showed no anatase lines; material was white with slight yellow cast	p; same as above	Synthetically prepared from doubly distilled clear and colorless TiCl ₄ , practically free of Fe, precipitated with ammonia, washed, dried, pulverized and heated 1.5 hr. at 930°C, and reheated several hr.
Stanton, W.O.	51-45	5388	TiO ₂ ; very pure single crystals of rutile and anatase	MP; visual observation of sample on Mo strip; optical pyrometer	Corrected 6°C for absorption by Vycor window in furnace
S. Pierre, P.D. &	52-74	3786-3822	TiO ₂ ; rutile with only trace of anatase. Several samples of specially pure oxide (0.04% Si; 0.02% Al; 0.01% Ca) and c.p. reagent grade (0.04% H ₂ O soluble salts; 0.001% ea. Zn, Pb; 0.00001% As)	MP; observation of cone collapse; 2 optical pyrometers	In oxidizing atmos.
Groves, W.O., Beach, M. and Hickman, H.L.	55-64	0	TiO ₂ ; "Bakers Analyzed" C.P. grade; 0.04% water soluble salts; 0.00% Pb; 0.003% Fe; 0.002% Zn; 0.00005% As	Ah ₂ ; from vapor pressure by Knudsen method	Vapor pressure measured 2868-3158°g
Lieta, J.	55-64	0	TiO ₂ ; prepared from TiO ₂ (see above) and iodide Ti containing 0.02% Ni, Te, Pb, Cu; 0.0032% Mn; 0.007% Al; 0.0066% Al	Ah ₂ ; same as above	Vapor pressure measured 2865-3082°g
McGraham, M.O., Sawicki, J. and Chupka, W.A.	56-64 also 57-65	536	TiO ₂	Ah ₂ ; from vapor pressure by Knudsen method with mass-spectrometer; optical pyrometer	
Lieta, J.	56-64 also 57-65	536	TiO	Ah ₂ ; same as above	Vapor pressure measured 3649-3730°g
Grim, M. & et al.	49-67	Room	98.7% TiO ₂ ; 0.91% SiO ₂ ; 0.40% Fe ₂ O ₃ . Porosity = 9.9%	p; Dry weight, water saturated weight and immersed weight	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1800°C. Unfired, dry bulk ρ = 161 lb _m /ft ³
Lieta, J.	49-67	Room	Same as above, porosity = 6.1%	p; Same as above	Same as above

PROPERTIES OF TITANIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
49-67	Griff. et al.	Room	98.7% TiO ₂ ; 0.93% SiO ₂ ; 0.40% Fe ₂ O ₃ ; Porosity = 6.5%	p: dry weight, water saturated weight and immersed weight	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1500°C. Unfired, dry bulk $\rho = 160 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 9.5%	p: same as above	Same as above, but unfired dry bulk $\rho = 166 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 6.0%	p: same as above	Same as above, but unfired, dry bulk $\rho = 162 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 10.6%	p: same as above	Same as above
49-67	Idid.	Room	Same as above, porosity = 37.9%	p: same as above	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1500°C, partially reduced to sub-oxides in graphite-resistor load-test furnace, held 3 hr. at 1500°C. Unfired, dry bulk $\rho = 152 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 37.6%	p: same as above	Same as above
49-67	Idid.	Room	Same as above, porosity = 21.0%	p: same as above	Same as above, but unfired, dry bulk $\rho = 161 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 39.4%	p: same as above	Same as above, but unfired, dry bulk $\rho = 154 \text{ lb}_m/\text{ft}^3$
49-67	Idid.	Room	Same as above, porosity = 40.9%	p: same as above	Same as above, but unfired, dry bulk $\rho = 155 \text{ lb}_m/\text{ft}^3$
57-150	Oak Ridge National Lab.	537	TiO ₂	p: weight in water and in kerosene	Measured by O. Sieman, C. D. Bopp and R. L. Towns

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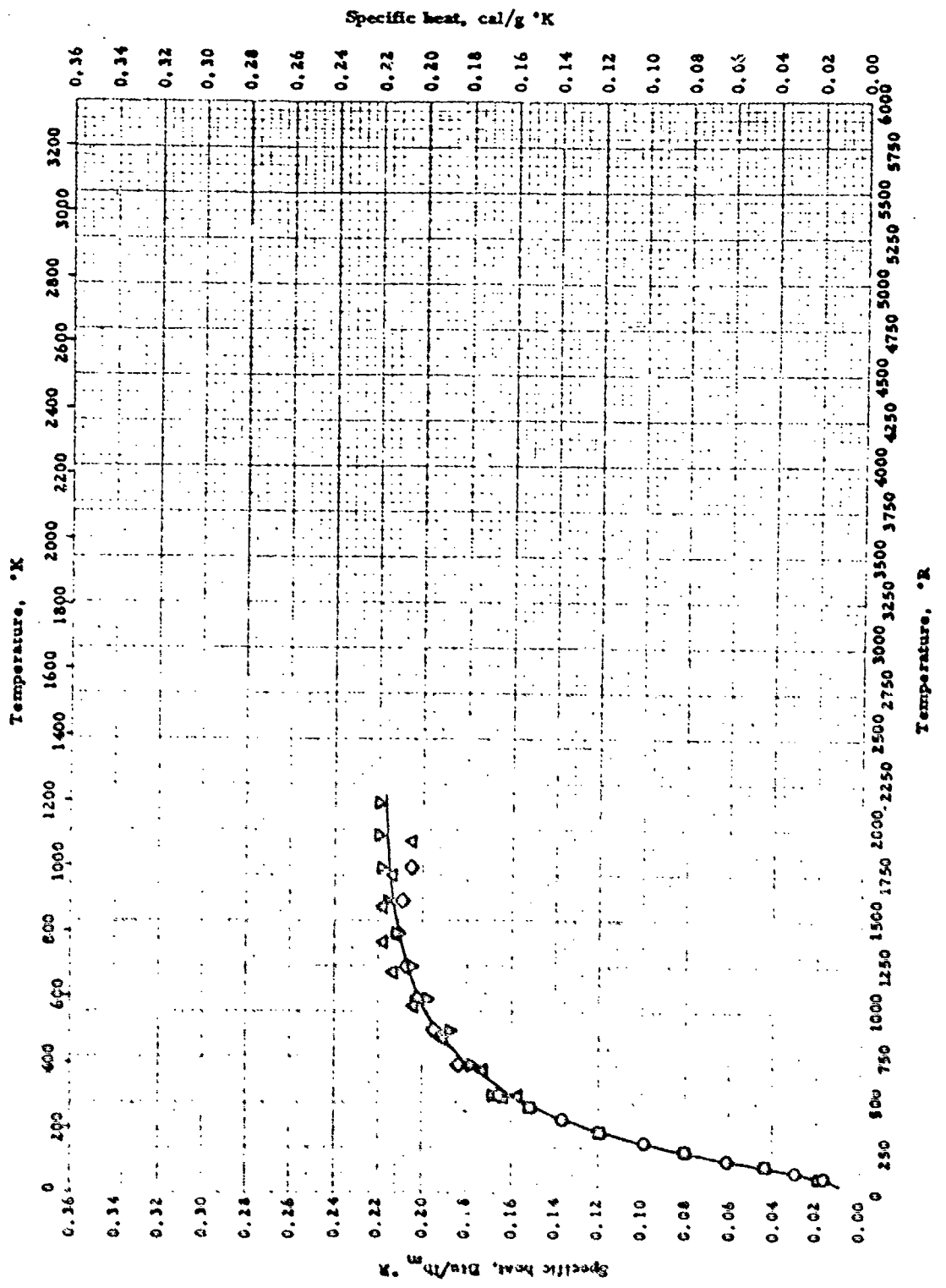
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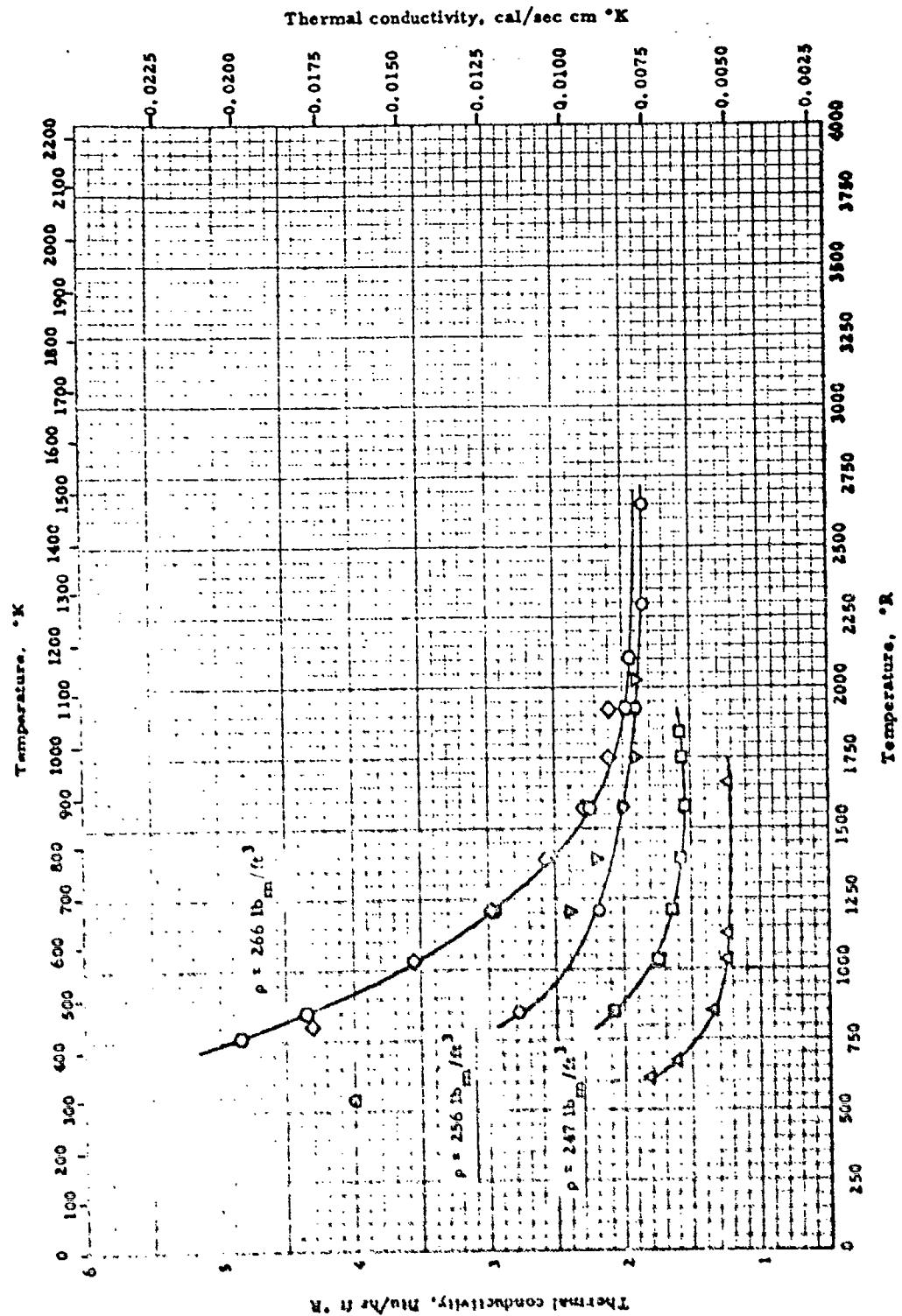


SPECIFIC HEAT -- TITANIUM OXIDE

SPECIFIC HEAT -- TITANIUM OXIDE

REFERENCE INFORMATION

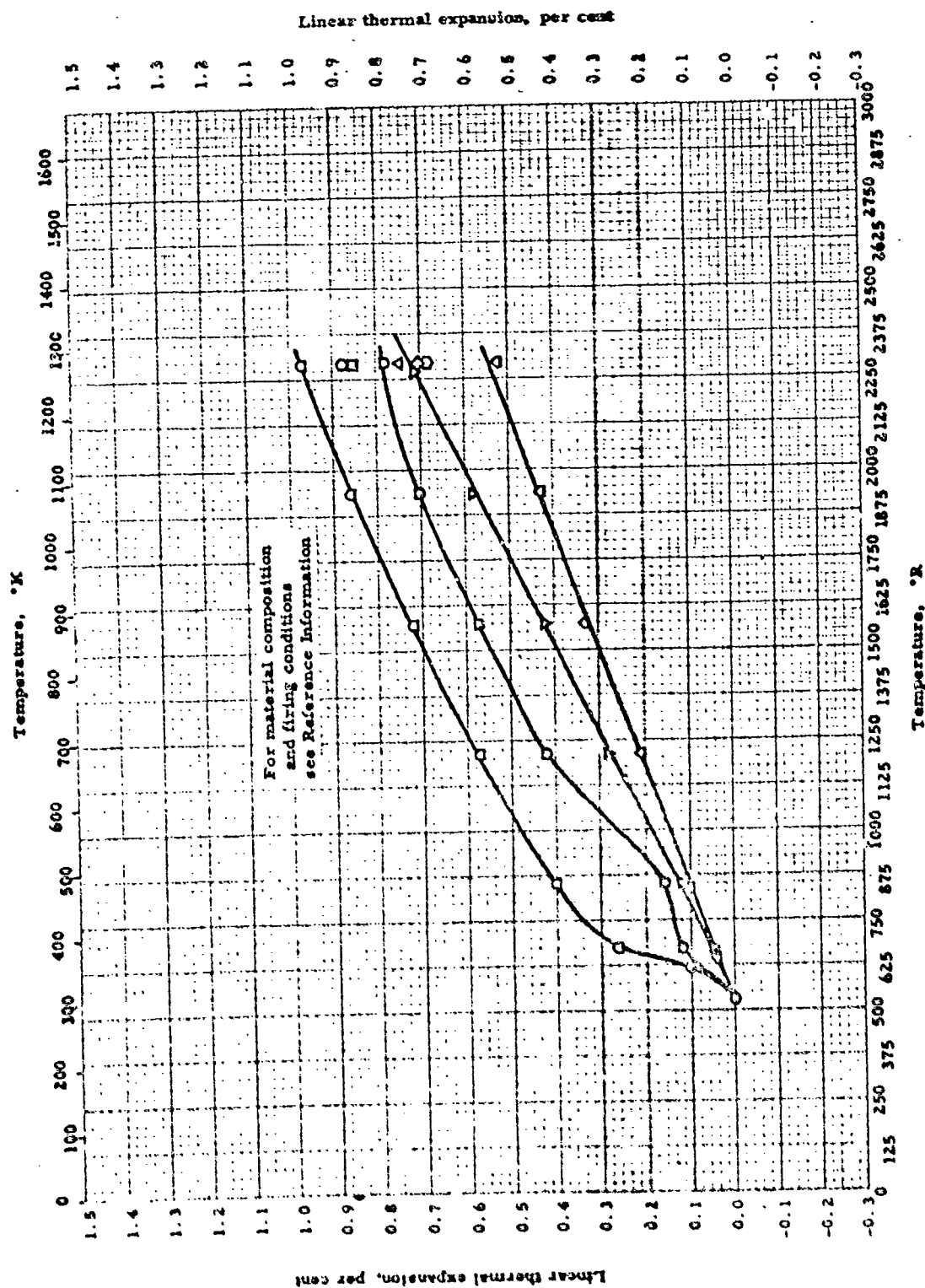
	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Enomata, C. H.	47-16	95-537	99.3% TiO ₂ ; 0.3% H ₂ O (Anatase) p = 242 lb _m /ft ³	Guarded sample	Corrected for H ₂ O. Auth. est. accuracy ± 0.3%
□	Ridd.	47-16	95-537	99.7% TiO ₂ (Rutile) p = 265 lb _m /ft ³	Same as above	Same as above
△	Arthur, J. S.	50-7	531-1932	Not given	Modified drop method; sample transferred manually from furnace to calorimeter	Doubtful accuracy
○	Lietz, J.	50-52	708-1788	TiO ₂ . X-ray showed only lines of Anatase. p = 243.7 lb _m /ft ³	Drop method; copper block calorimeter	Synthetically prepared from doubly distilled TiCl ₄ . Heated 4 hr. at 565°C
▽	Ridd.	56-52	124-2148	TiO ₂ (Rutile); x-ray showed no lines of Anatase; p = 259.1 lb _m /ft ³	Same as above	Same as above except heated 1.5 hr. at 930°C. Material was white with slight yellow cast



THERMAL CONDUCTIVITY -- TITANIUM OXIDE

REFERENCE INFORMATION

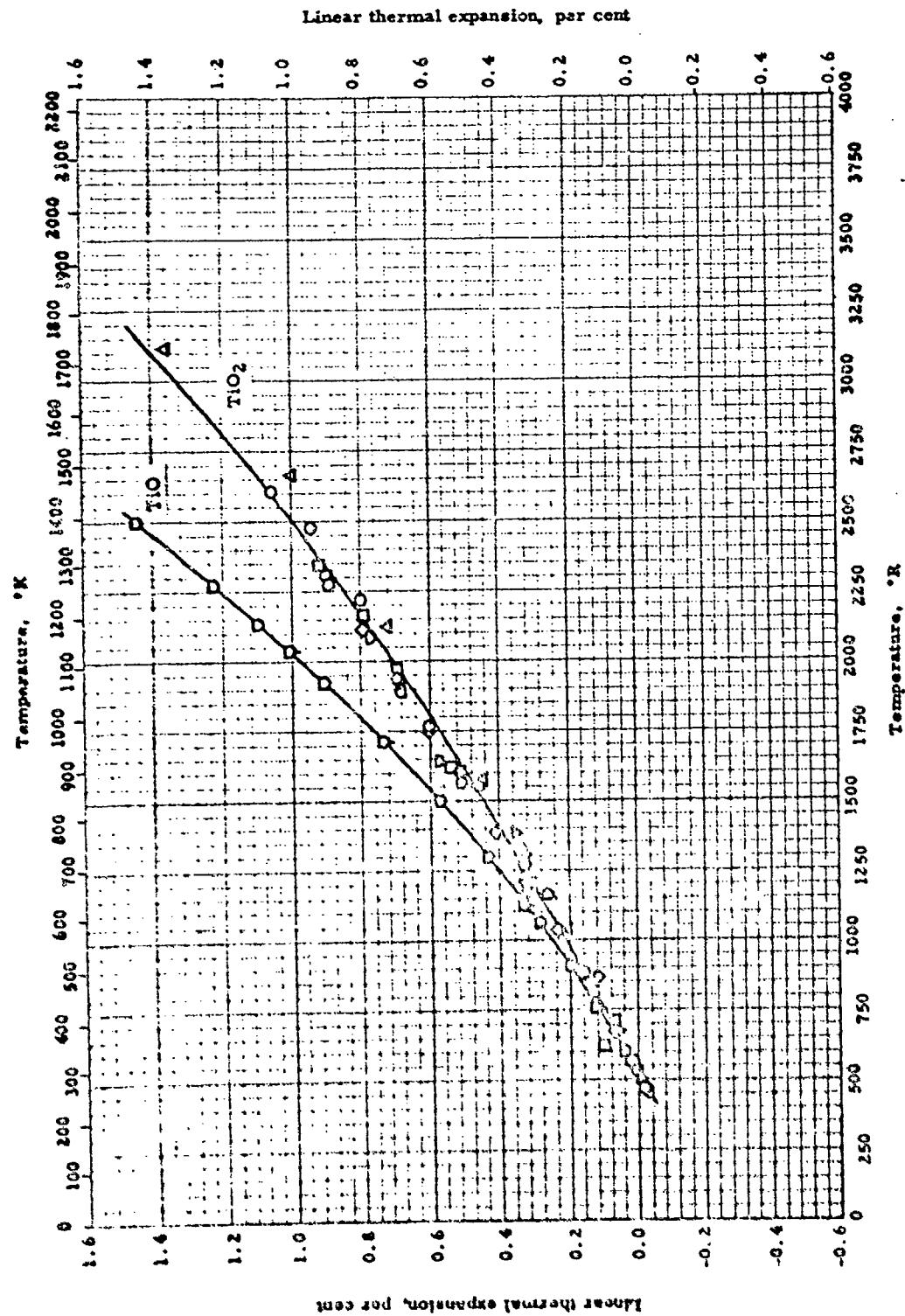
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Kingery, W. D. and Frankel, J.	54-1 also 52-65 53-65	852-2652	Chemically pure TiO_2 ; $\rho = 257 \text{ lb}_m/\text{ft}^3$ (cf. theor. $\rho = 266$) Porosity = 3.5%	Ellipsoidal envelope	Calcined at 1000°C, acid leached, slip cast and fired at 1700°C in oxidizing atmos.
Bassett, W. R. and Bush, E. A.	55-10	852-1842	Dense TiO_2 ; made from 100% heavy grade TiO_2 ; binder consists of 500 g Carbowax, 10 g methocel and 7% water; $\rho = 247 \text{ lb}_m/\text{ft}^3$. Apparent Porosity = 0.1%	Radial heat flow in cylinder	Samples pressed at 4400 psi and fired 20 min. at 1390°C
Idid.	55-10	618-1662	Porous TiO_2 ; made from 70% titanox calcined 1 hr. at 1500°C and 30% RA-10-MO. Binder consisted of 500 g carbowax, 10 g methocel and 7% water; $\rho = 207 \text{ lb}_m/\text{ft}^3$. Porosity = 17.1%	Same as above	Samples fired for 1 hr. at 1390°C
Kingery, W. D. and Norton, F. H.	55-47	672-1932	TiO_2 ; Porosity = 2.1%. Average crystal size = 15 microns	Comparative; rods	Sintered 2 hr. at 1250°C
Idid.	55-47	1212-2022	TiO_2 ; Porosity = 3.0%. Average crystal size = 28 microns	Same as above	Sintered 8 hr. at 1450°C
Charvat, F. R. and Kingery, W. D.	57-53	762-2112	Polycrystalline; TiO_2 Porosity = 2.1%. Average crystal size = 15 microns	Comparative; cubes	Data corrected to zero porosity
Oak Ridge National Laboratory	57-150	546	TiO_2	Not described here; refers to others	Measured by O. Sieman, C. D. Bobb and R. L. Towns, Auth. etc., accuracy $\pm 12\%$



LINEAR THERMAL EXPANSION -- TITANIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
W. W. and H. A.	51-48	528-2292	97% TiO ₂ ; 3% SiO ₂	Quartz tube dilatometer using dial gauges calibrated to 10 in.	Heated 2 hr. at 1540°C and 8 hr. at 1500°C
Id.	51-48	528-2292	92% TiO ₂ ; 8% SiO ₂	Same as above	Same as above
Id.	51-48	528-2292	84% TiO ₂ ; 16% SiO ₂	Same as above	Same as above
Id.	51-48	528-2292	76% TiO ₂ ; 24% SiO ₂ , Sample 1	Same as above	Same as above
Id.	51-48	672-2292	Same as above, Sample 2	Same as above	Same as above
Id.	51-48	528-2292	67% TiO ₂ ; 33% SiO ₂	Same as above	Same as above
Id.	51-48	618-2292	57% TiO ₂ ; 43% SiO ₂	Same as above	Same as above
Id.	51-48	672-2292	Same as above	Same as above	Same as above, fired 1 hr. at 1670°C
Id.	51-48	672-2292	56% TiO ₂ ; 42% SiO ₂ ; 2% GeO ₂	Same as above	Same as above, but fired at 1540°C



LINEAR THERMAL EXPANSION -- TITANIUM OXIDE.

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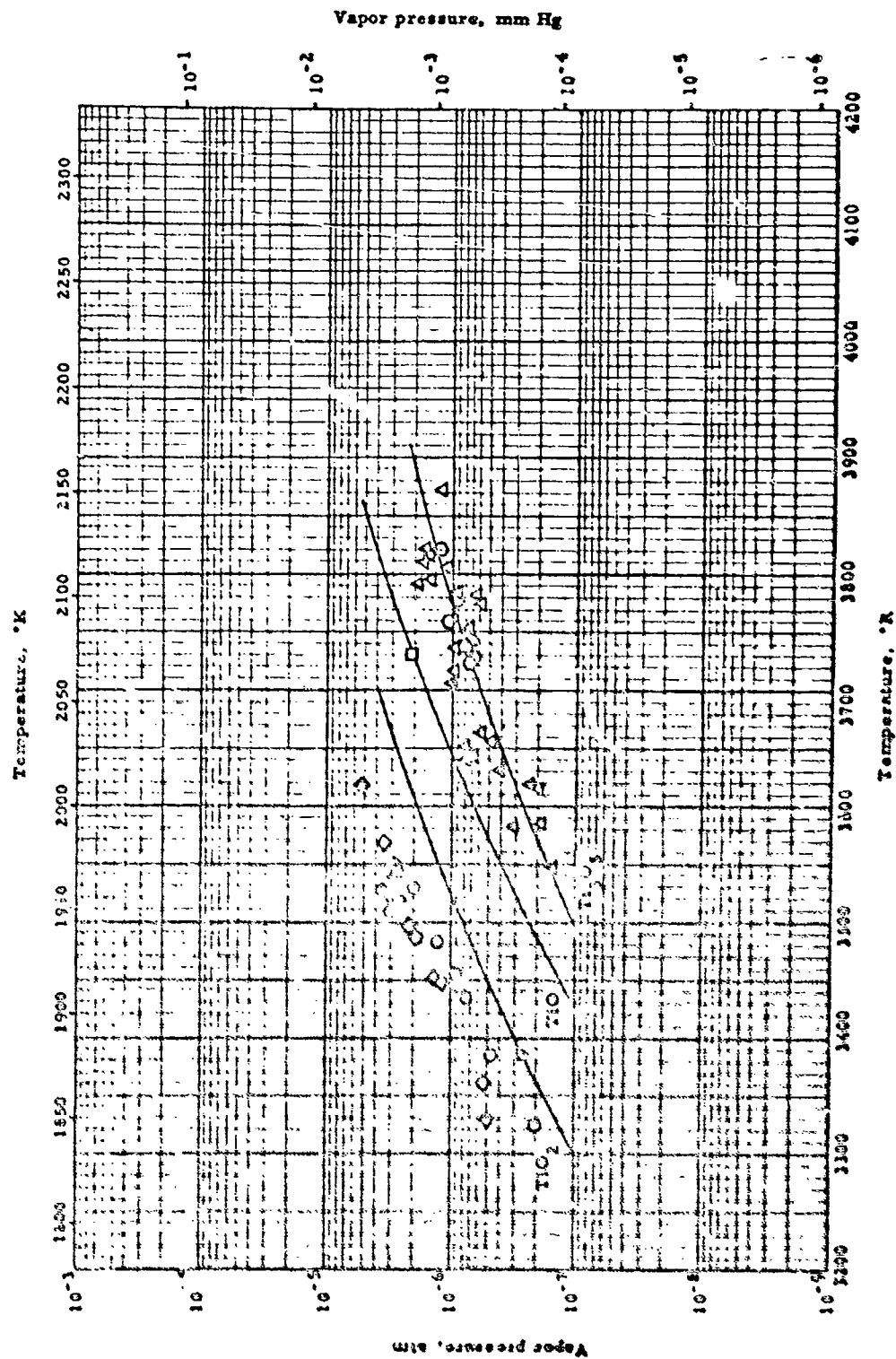
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LINEAR THERMAL EXPANSION -- TITANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-8	Mauer, F. A. and Bolz, L. H.	492-2607	TiO ₂	Dilatometer	Air atmos.
56-8 also 54-19 54-51 57-62 55-58	Idid.	492-2351	Same as above	X-ray diffraction; averaged expansion along "a" and "c" axes to represent polycrystalline solid	Fired at 1700°C in oxidizing atmos. then ground to 325 mesh and pre-sintered at 1200°C in air; tested in He atmos.
56-7	Whittemore, O. J. and Jahn, R. N.	1032-3102	Coarse fused grains TiO ₂	Telemicroscopes sighting on pointed ends of sample	
47-9	Verling, E. N., and Graham, A. E.	528-2112	C. P. grade TiO ₂	Interferometer	Heated 12 hr. at 1100°C, matured 6 hr. at 1250-1430°C
41-9	Norris, L.	528-1392	90% TiO ₂ ; 3.4% ea. CaTiSiO ₃ , MgO, BeO	Comparison with standard (not identified) of similar length	
55-58	Mauer, F. A. and Bolz, L. H.	492-1235	TiO ₂ ; 97% oxygen deficient rutile; "Black Rutile" prepared by heating TiO ₂ to 1338°C in vacuum	X-ray diffraction	
51-48	Richter, R. W. and Whittemore, F. A.	528-2292	100% TiO ₂	Fused silica dilatometer	Fired 2 hr. at 1540°C and 8 hr. at 1500°C
51-48	Idid.	528-2292	Same as above	Same as above	Fired 18 hr. at 1080°C
56-8 also 57-62	Mauer, F. A. and Bolz, L. H.	492-2503	TiO	Dilatometer	In vacuum. Q - heating; Q - cooling
56-8	Idid.	492-1604	TiO	X-ray	He atmos. Above 600°C x-ray patterns were poor; after heating sample above 600°C, room temp. patterns also were poor



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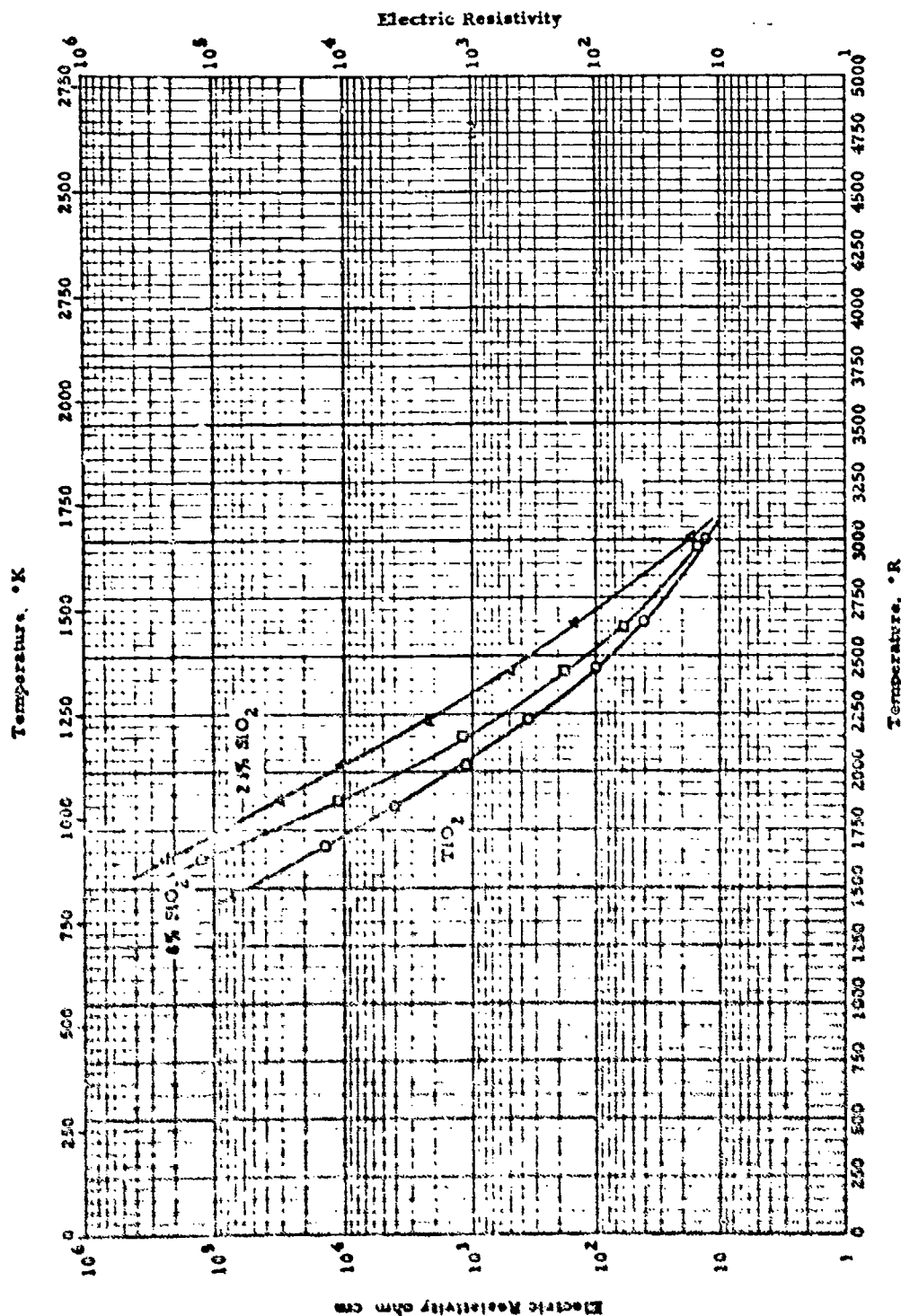
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VAPOR PRESSURE -- TITANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Groves, W. O., Fock, M., and Johanson, H. L.	55-64	3325-3542	TiO; actually TiO _{1.029} for two points; TiO _{1.029} for others; prepared from "Baker's Analyzed" cp. TiO ₂ and iodide process Ti	Knudsen effusion cell; with x-ray diffraction camera	Ta cell, degassed, corrected for weight loss. Additional oxygen in solid to inhibit TiO(s) + TiO ₂ (s) + Ti(g)
Idid.	55-64	3548-3872	Ti ₂ O ₃ ; raw materials same as above	Same as above	Mo lined Ta cell, degassed, corrected for weight loss. Ti ₂ O ₃ (s) + TiO(g) + TiO ₂ (g). Auth.'s state that the assumption: $P_{TiO} = P_{TiO_2}$ introduces error of only 0.47%, therefore report results as $\sqrt{P_{TiO} \cdot P_{TiO_2}}$
Idid.	55-64	3528-3618	TiO ₂ ; actually TiO _{1.9} ; raw materials same as above	Same as above	Mo lined Ta cell, degassed, corrected for weight loss. TiO _{1.9} used to inhibit effusion of O ₂ , for detailed explanation. See p.129 of article
Idid.	55-64	3723-3820	Ti ₂ O ₃ ; raw materials same as above	Same as above	Data treated as Ti ₂ O ₃ (s) + Ti ₂ O ₃ (s) + TiO ₂ (g); results reported as P_{TiO_2}
Borodits, J., Cusack, W. A., and Liggett, M. G.	57-65 also 56-64	3736	TiO	Knudsen effusion cell and mass spectrometer	Mo lined Ta cell and Thoria cell. Auth.'s state $P_{TiO} = P_{TiO_2}$ in spite of small amount of additional oxygen
Idid.	57-65 also 56-64	3730	Ti ₂ O ₃	Same as above	No p results given, however auth. state that $P_{TiO} : P_{TiO_2} : P_{TiO_2} = 600 : 1400 : 17$ in contradiction to Groves et al.
Idid.	57-65 also 56-64	3886	TiO ₂	Same as above	Mo lined Ta cell and Thoria cell. Results with first cell affected by evolution of large amounts of Mo oxides



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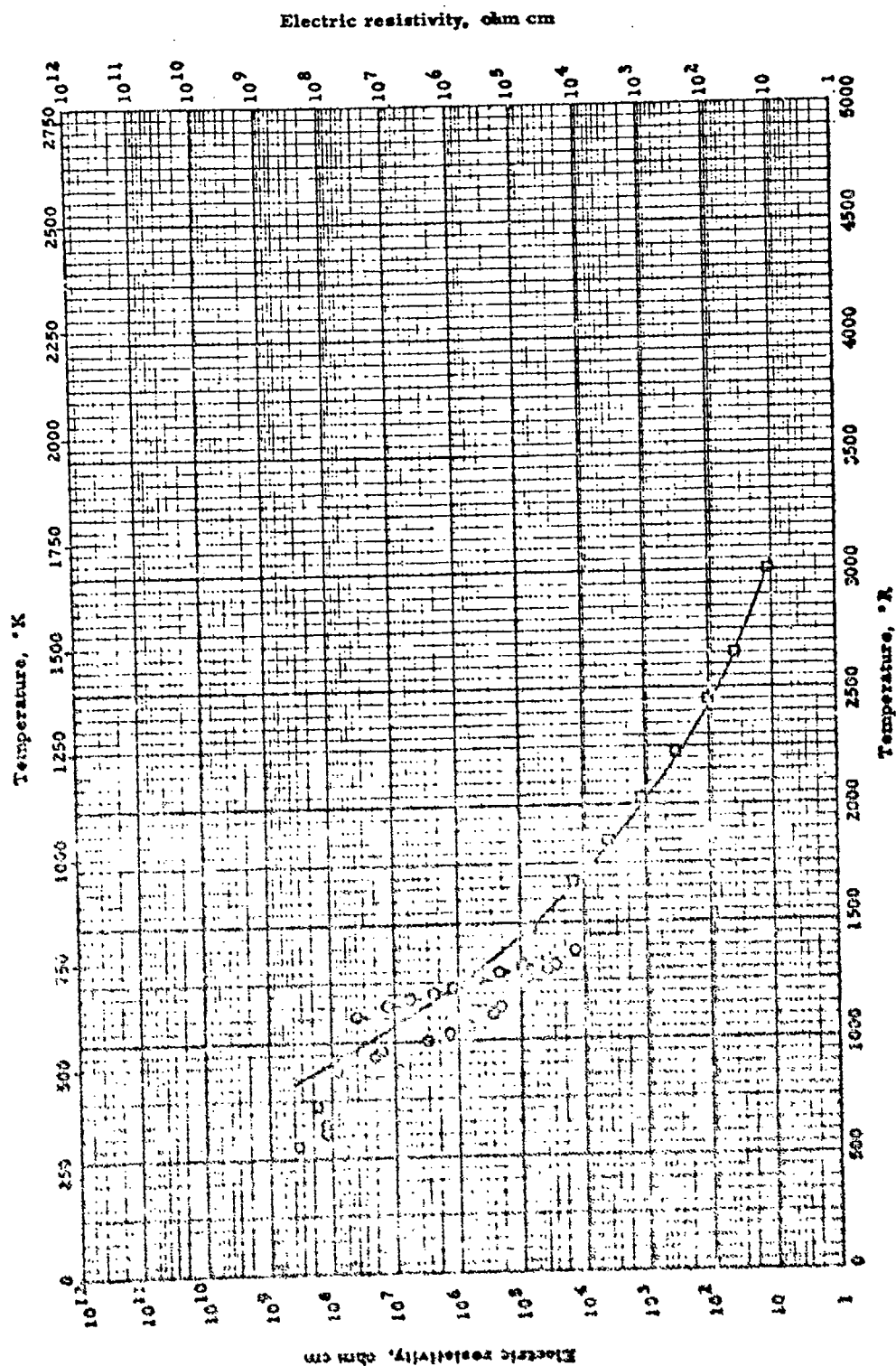
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ELECTRIC RESISTIVITY -- TITANIUM OXIDE + SILICON OXIDE

ELECTRIC RESISTIVITY -- TITANIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Moncher, J. R. and Henry, R. C.	53-95	1432-3012	100% TiO ₂	Wheatstone bridge	Fired 24 hr. to 1450°C
Q	2nd.	53-95	1624-3012	92% TiO ₂ ; 8% SiO ₂	Same as above	Same as above
A	2nd.	53-95	1624-3012	76% TiO ₂ ; 24% SiO ₂	Same as above	Same as above



ELECTRIC RESISTIVITY -- TITANIUM OXIDE

ELECTRIC RESISTIVITY -- TITANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Johnson, G.H.	53-104	546-1959	Chemically pure TiO_2 ; rutile	Wheatstone bridge	Q - heating Q - cooling Fired 74 hr. to 1450°C
Reeder, J.R. and Henry, E.C.	53-95	5432-2012	TiO_2	Wheatstone bridge	

PROPERTIES OF HAFNIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	604 lb _m /ft ³ *	9.68 g/cm ³ *
Melting Point.	5729°R	3170°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook of Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
 O 5721 ± 45 3173 ± 25
 □ 5553 3085

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF HAFNIUM OXIDE

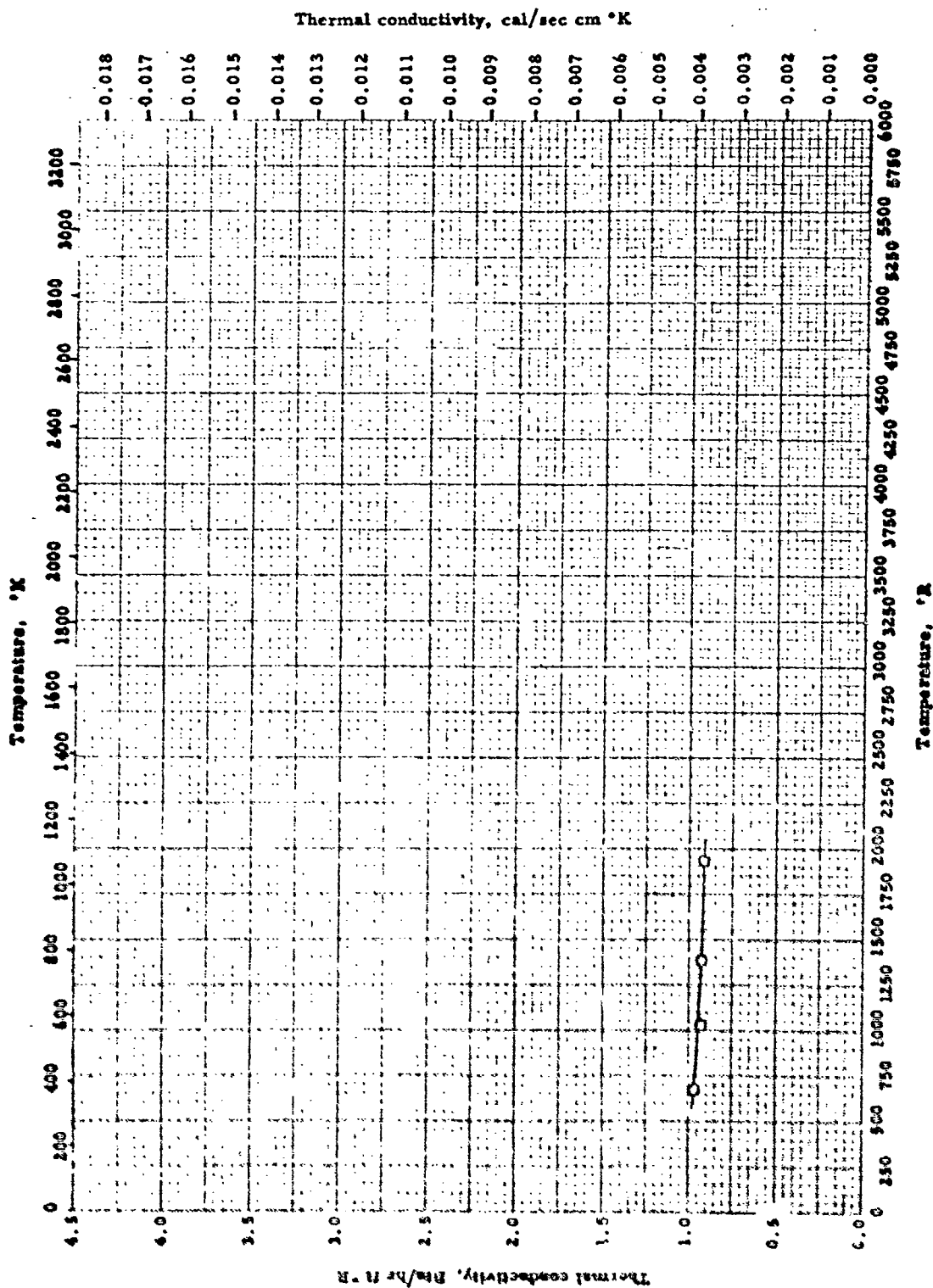
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Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Curtis, C. E., Downey, L. M., and Johnson, J. R.	54-46 also 54-45	5721	0.1% Ti; 0.06% Al; 0.01% ea. Fe, Si; 0.0002% Zr	MP; sample heated with oxyacetylene flame; op- tical pyrometer	Ground to 325 mesh; pressed at 20,000 psi; fired 2 hr. at 1600°C
2	Trombe, F.	49-16	5554	Not given	MP; not given	

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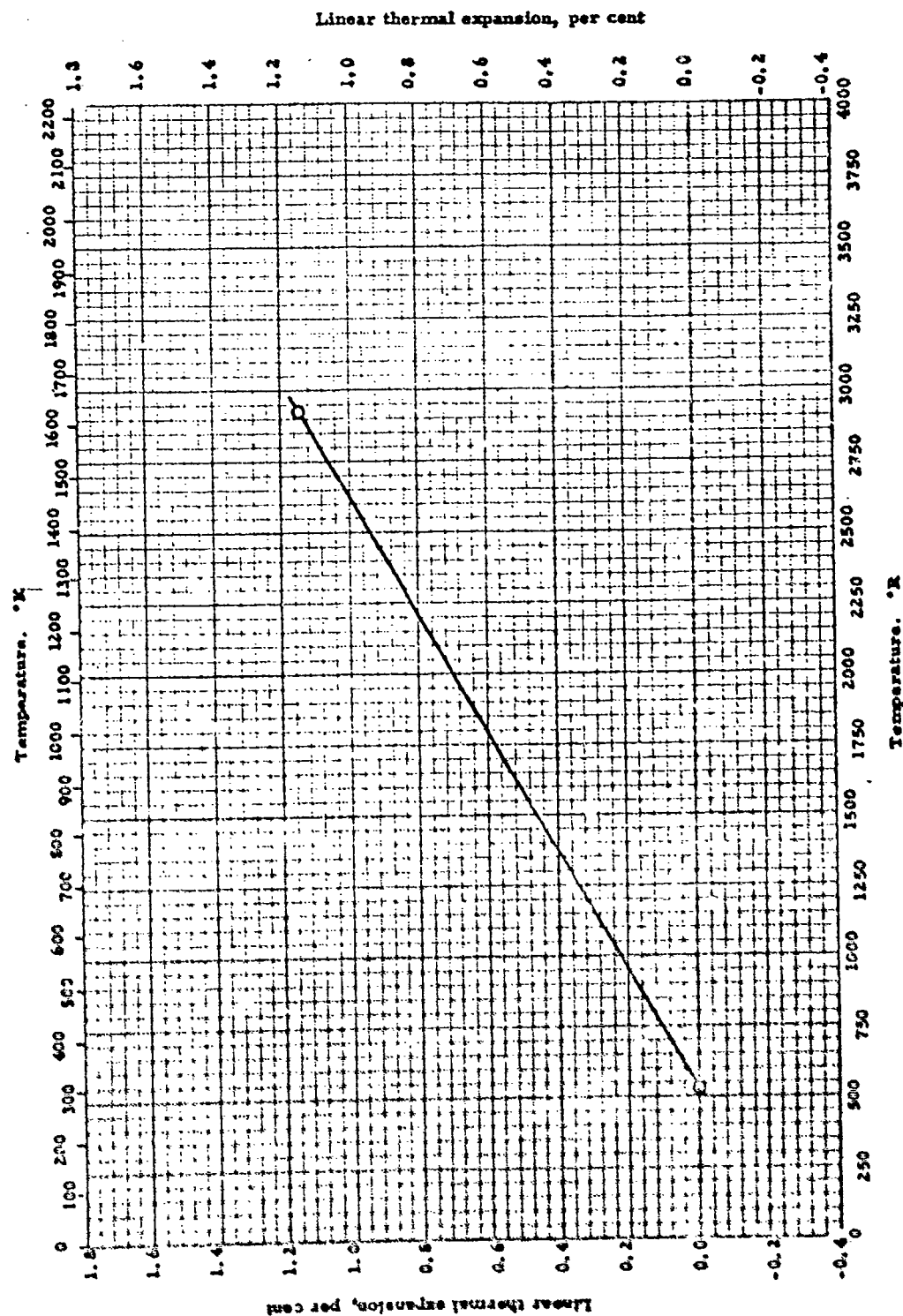
Thermal conductivity -- hafnium oxide

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THERMAL CONDUCTIVITY -- HAFNIUM OXIDE

REFERENCE INFORMATION

Author	Ref.	Range, °F.	Material Composition	Test Method	Remarks
Johnson, F. H., and Lindberg, W. D.	55-25	672-1932	Not given	Comparative; rods	



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- LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE + TANTALUM OXIDE

LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE + TANTALUM OXIDE

REFERENCE INFORMATION

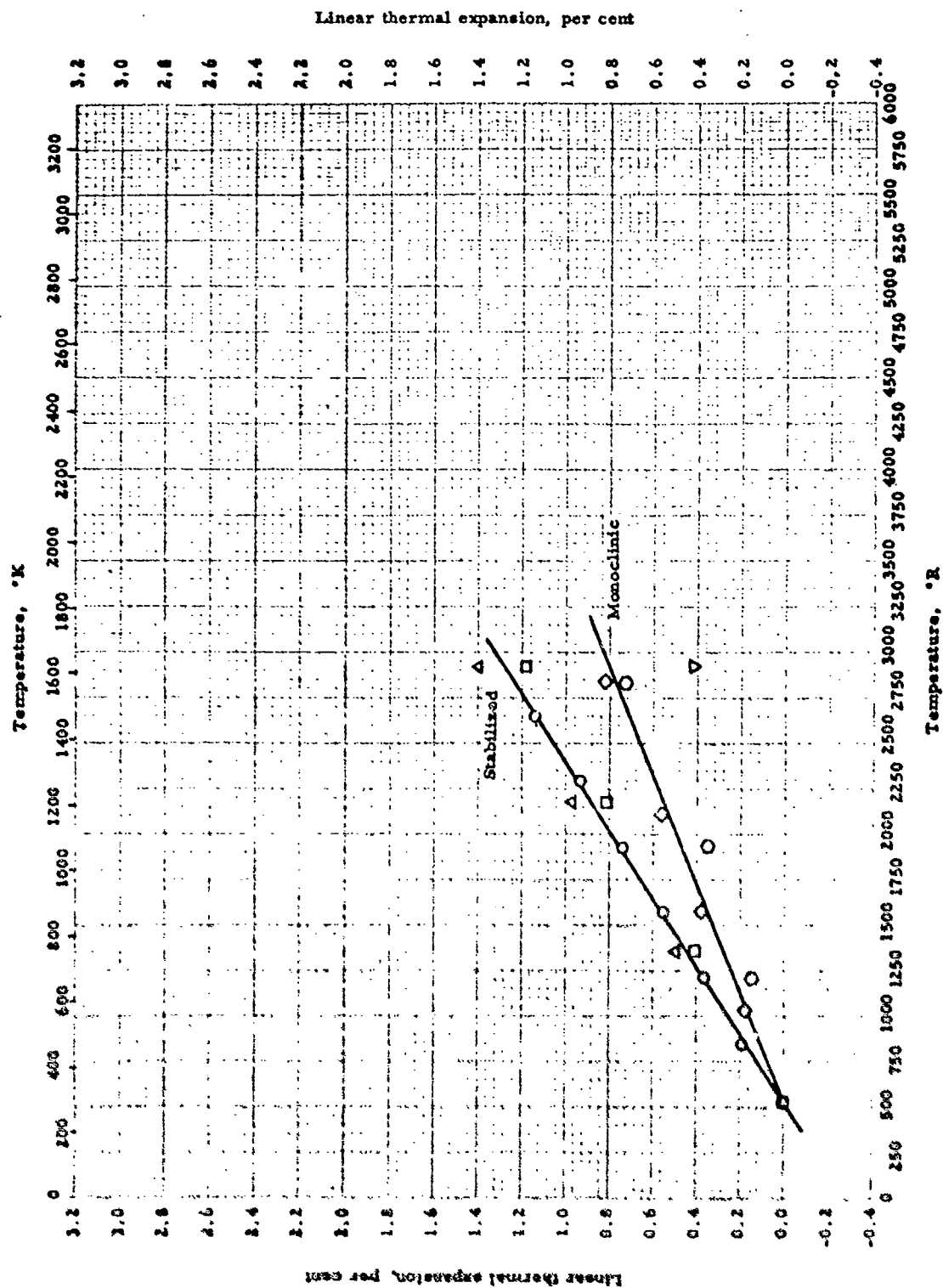
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Cluse, C. F. and Lewis, C.	57-23	528-2922	$6\text{HfO}_2 \cdot \text{Ta}_2\text{O}_5$	Not given	Ta ₂ O ₅ impurities: 1% ea. Ta, Si; 0.05 - 0.1% F, Ti; HfO ₂ impurities: 1% Ta; 0.05-1% V; 0.1-0.5% Na; 0.1-0.05% ea. Al, Ti

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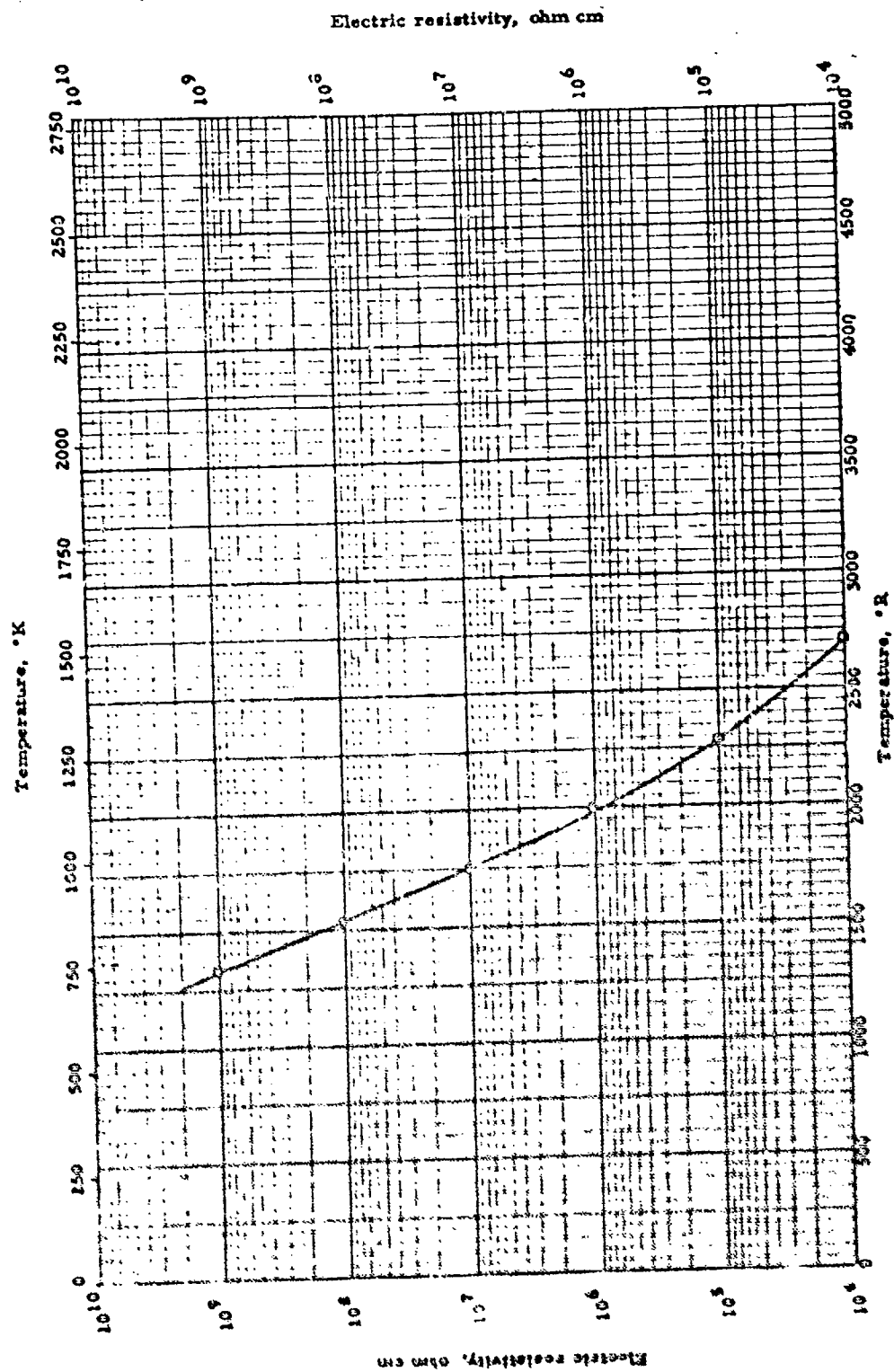


LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE

LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O Curtis, C. E., Doney, L. M. and Fellmann, J. R.	54-45 also 54-46	525-2832	97.7% HfO_2 ; 2.3% CaO ; $\rho = 524 \text{ lb./ft}^3$; porosity = 10%; (92 mol % HfO_2 ; 8 mole % CaO)	Sapphire dilatometer	Mixed, pressed at 20,000 psi. Soaked 2 hr. at 1650°C
Trid.	54-45 also 54-46	525-2832	Unstabilized hafnia. Monoclinic; 0.14% Ti; 0.1% ea. Fe, Si; 0.06% Al; 0.0002% Zr	Same as above	Ground to 325 mesh, pressed at 20,000 psi, fired 2 hr. at 1600°C; tested at 3°C/min. rise
Q Cliza, C. F. and Lewis, G.	57-23	525-2292	97.9% HfO_2 ; 2.1% MgO ; (90 mol % HfO_2 ; 10 mol % MgO)	Not given	Auth. report mean expansion coeff. over range
A Trid.	57-23	525-2292	95.4% HfO_2 ; 4.4% MgO ; (80 mol % HfO_2 ; 20 mol % MgO)	Same as above	Same as above
V Trid.	57-23	525-2292	Unstabilized hafnia. 1% excess Hf; 1% Zr; 0.5-1.0% ea. Fe, Si; 0.1-0.5% Mg; 0.05-0.10% ea. Ti, Ca; 0.005-0.010% Al; 0.001-0.005% ea. Mn, Co	Same as above	Auth. report mean coeff. of exp. = 3.18 $\times 10^{-6}/^\circ\text{C}$ for range 20-1350°C
U Fullerton, E. D.	57-159	850-2830	Unstabilized hafnia. HfO_2 , Zr free	Sapphire dilatometer	Monoclinic form of crystal



ELECTRIC RESISTIVITY -- HAFNIUM OXIDE

ELECTRIC RESISTIVITY -- HAFNIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
G	Curtis, C.E., Doney, L.M. and Johnson, J.R.	54-45	1212-3192	Hafnium oxide; 0.1+% Ti; 0.1% ea. Fe, Si; 0.06% Al; 0.0002% Zr	Not given	Work done at NBS. Material ground to pass 325 mesh, pressed at 20,000 pni with 5% water and 2% dextrin; fired 2 hr. at 1600°C

Symbol	Material Composition, %		Density	
	ZrO ₂	UO ₂	lb m / ft ³	g / cm ³
O	90	10	323	5.18
□	85	15	340	5.45

DENSITY -- ZIRCONIUM OXIDE + URANIUM OXIDE

①

60-768

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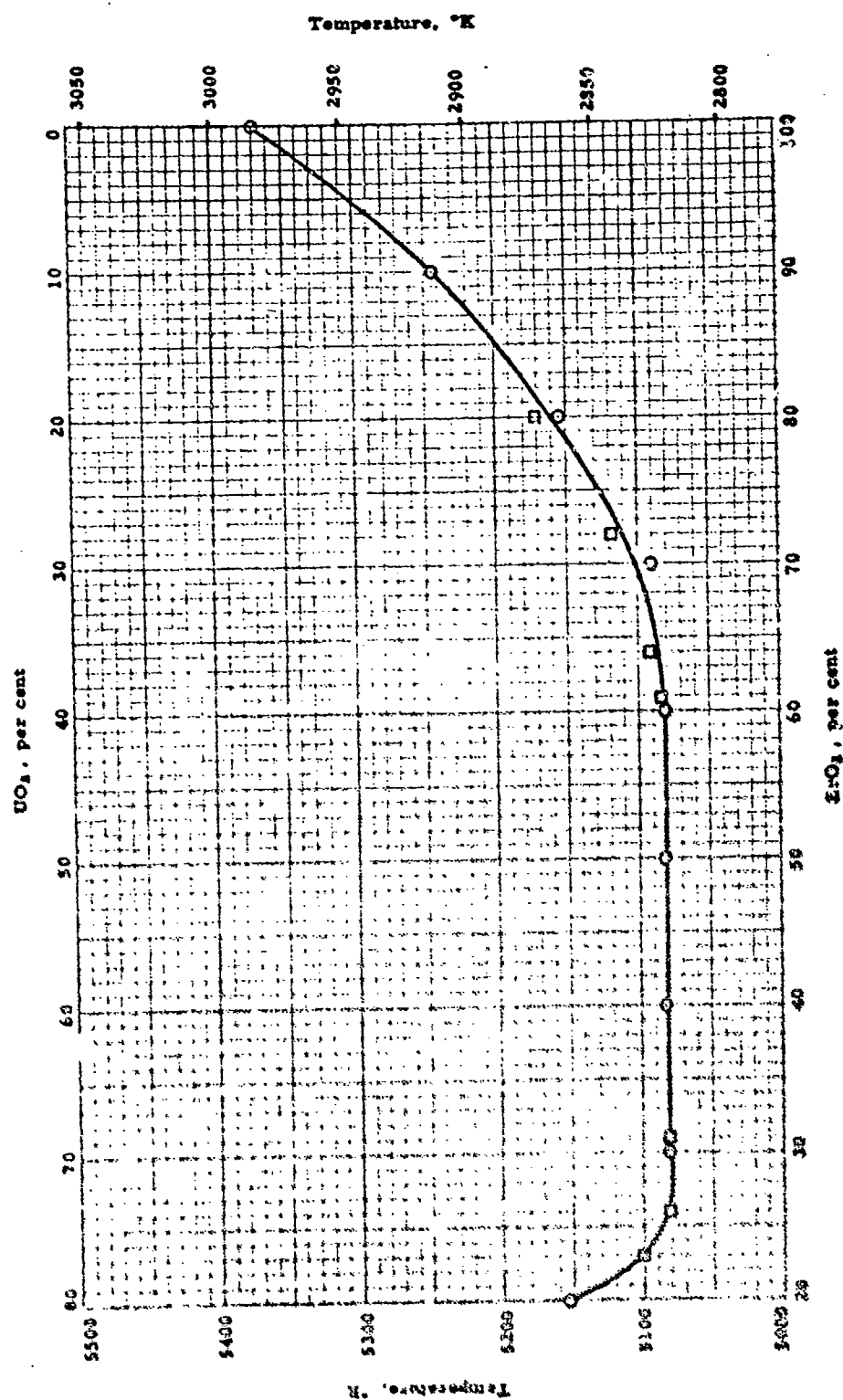
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DENSITY -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
56-156	Malba, J. and Jacet, L. J.	56-156	Room	90% ZrO ₂ ; 10% UO ₂	Not given	Pressed at 80,000 psi, sintered 16 hr. at 1700°C
56-156	Malba, J. and Jacet, L. J.	56-156	Room	85% ZrO ₂ ; 15% UO ₂	Same as above	Pressed at 80,000 psi, sintered 16 hr. at 1700°C



MELTING POINT -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Order No.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
Q	Lambertson, W. A. and Mueller, M. H.	51-158	5082-5372	Binary series $ZrO_2 - UO_2$	Not given	Made from approx. 98% pure ZrO_2 with 2% H_2O_2 and 0.035% other impurities and probably pure UO_2
Q	Did.	51-158	5082-5372	Same as above	Same as above	Same as above

<u>Symbol</u>	<u>Nominal Composition</u>	<u>Melting Point</u>	
		<u>°R</u>	<u>°K</u>
○	3 ZrO ₂ + 5 BeO + 4 MgO	3540 ± 8	1966 ± 5
□	ZrO ₂ + Nb ₂ O ₅	3111	1728
	2 ZrO ₂ + Nb ₂ O ₅	3228	1784
	3 ZrO ₂ + Nb ₂ O ₅	3228	1784
	4 ZrO ₂ + Nb ₂ O ₅	3147	1748

MELTING POINT -- ZIRCONIUM OXIDE + OTHER OXIDES

MELTING POINT -- ZIRCONIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-132	National Bureau of Standards	1532-1548	$3ZrO_2 + 5BaO + 4MgO$	MP: visual observation; temp. by optical pyrometer	Average of 3-5 tests; auth. test, accuracy $\pm 2^\circ$
52-31	Durbán, E. A. and Harman, C. G.	3111-3228	$ZrO_2 + Nb_2O_5$ series	MP: meas. fusion temp. during sintering	Prepared from 99.5% ZrO_2 and 99.9% Nb_2O_5 , sintered

PROPERTIES OF ZIRCONIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	360 lb _m /ft ³	5.7 g/cm ³
Melting Point.	5370°R	2980°K
Heat of Fusion.		
Heat of Vaporization. . .		
Heat of Sublimation. . . .	3700 °R Btu/lb _m	1500 °K cal/g

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
Δ	362	5.80
◇	356	5.70
▽	182	2.92
○	337	5.4

<u>Melting Point:</u>	°R	°K
□	5080	2822
◇	5532 ± 45	3123 ± 25
○	5352	2973
□	5370 ± 27	2983 ± 15
△	5369 ± 18	2983 ± 10
▽	5612 ± 233	3118 ± 130
Δ	4452	2473

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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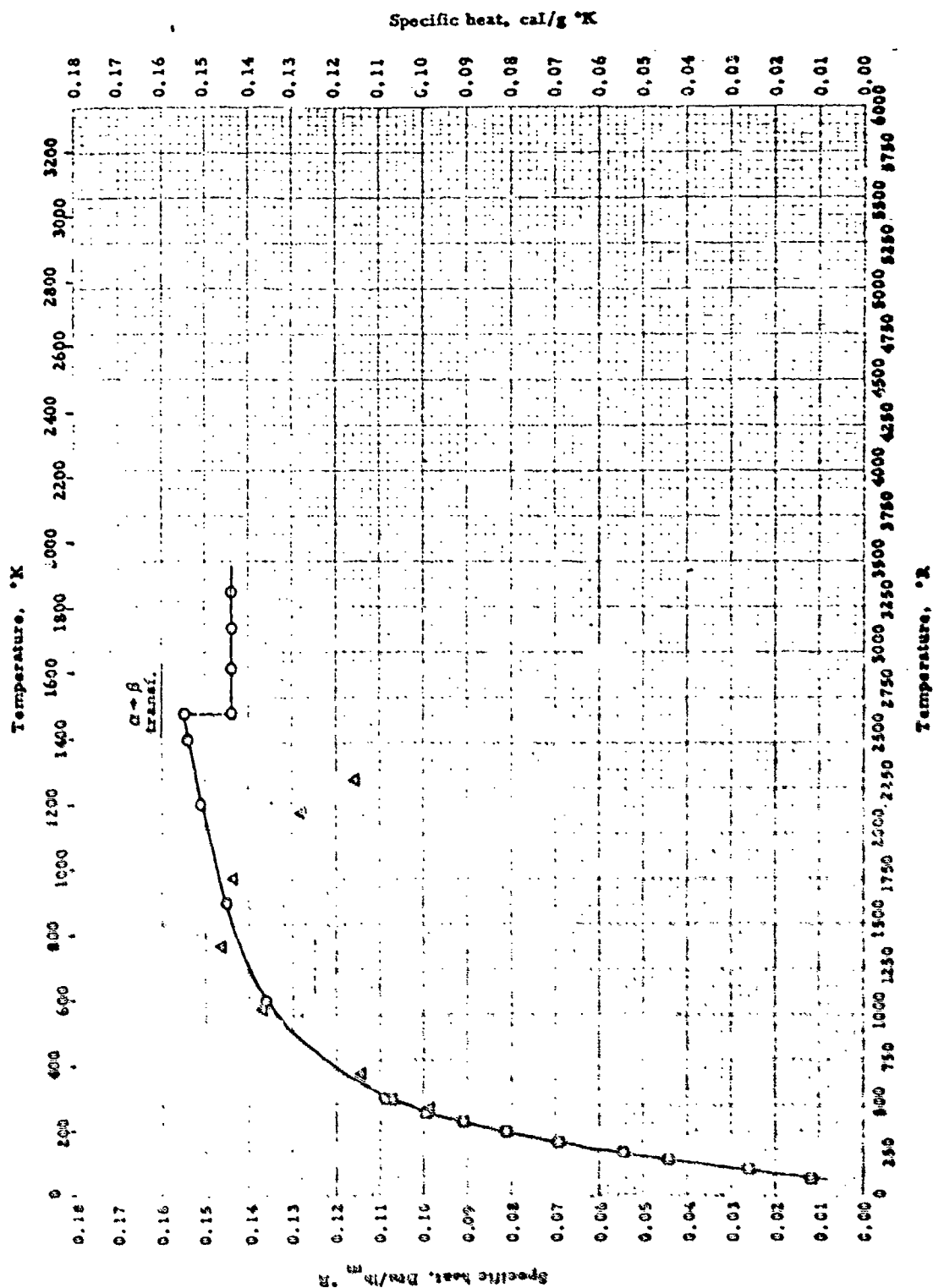
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
○	2050 3870°R ± 22	1139 2150°K ± 12
▽	2717 °R	1509 °K
○	2295 °R	1277 °K ± 8

PROPERTIES OF ZIRCONIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Neub, M., Fisher, M. L. and Fisher, H. L.	51-24	1570	ZrO ₂ . Metal content 99.54% Zr; < 0.025% Hf	ΔH_f from vapor pressure data by Knudsen method with optical pyrometer $\pm 5^\circ\text{C}$	B.P. given as 3735°K. Vapor pressure measured 3625-4122°R
D	Williams, O. J.	51-4	5000	Stabilized zirconia	MP; not given	General comment in trade journal; no other information given
A	Gaugler, J. J.	50-10 also 49-20	Room	Stabilized zirconia: 73.44% Zr; 25.43% O ₂ ; 0.16% combined C; < 0.01% free C	p: weight in air and in dis- tilled water	Hot pressed in graphite mold. Auth. quotes theoretical p = 6.1 g/cm ³
C	Currie, C. E., Doney, L. M., and Johnson, J. R.	54-45 also 54-46	5532	0.95% Fe; 0.02% S; 0.015% Al; 0.008% Hf; 0.006% Ti	MP; heated with oxyacetylene flame; optical pyrometer	Ground to 325 mesh; pressed at 20,000 psi; fired 2 hr. at 1600°C
D	Chenka, W. A., Rajaratnam, J., and Rajaratnam, M. C.	ND-2	0	ZrO ₂	ΔH_f from vapor pressure data by Knudsen method with mass spectrometer; optical pyrometer	Vapor pressure measured 4196 - 4444°R
C	Trumble, F.	49-16	5552	ZrO ₂	MP; not given	
C	Lambertson, W. A. and Gustaf Jr., F. H.	52-131	200-250	ZrO ₂ 2.03% HfO ₂ ; 0.03% other	MP; visual observation after heating in constant temp. fur- nace; optical pyrometer	
C	Lambertson, W. A. and Mueller, M. H.	53-456	500-550	Zirconia. 2.0% HfO ₂ ; 0.02% SiO ₂ ; 0.005% ea. CeO ₂ , Fe ₂ O ₃ ; 0.002% MnO; 0.001% Al ₂ O ₃ ; Na ₂ O; 0.005% BaO; 0.002% Cr ₂ O ₃ ; 0.003% Ba ₂ O ₃	MP; not given	
C	Neub, M., Nekara, M. and Johnson, H. L.	54-456	0	Zirconia. 0.025% Hf.	ΔH_f ; not given	ZrO ₂ (s) → ZrO ₂ (g). Auth. also test- ed mixture of ZrO ₂ + Zr to check on undissociated gas phase. Auth. recommends ΔH (k cal/mole) = 157, 300-7.80°C-400,000T ⁻¹ (T in °K). Also ΔH dissociation ZrO ₂ (g) → Zr(g) + O ₂ (g) = 368 ± 5 k cal/mole
C	Gubelstein, D.	50-36	2079-2865	ZrO ₂	MP; visual observation. Temp. by optical pyrometer	
A	O'Connor, W. F., Lester, T. E. et al.	51-47	4452	ZrO ₂	Temp. by optical pyrometer	
C	Johnson, P. D.	50-37	Room	ZrO ₂	p: computed from x-ray measurements of lattice	Pressed at 52,000 psi
D	Shah.	50-37	Room	ZrO ₂	p; not given	Fired at 2100-2300°C
D	Shah.	50-37	Room	ZrO ₂	p; not given	

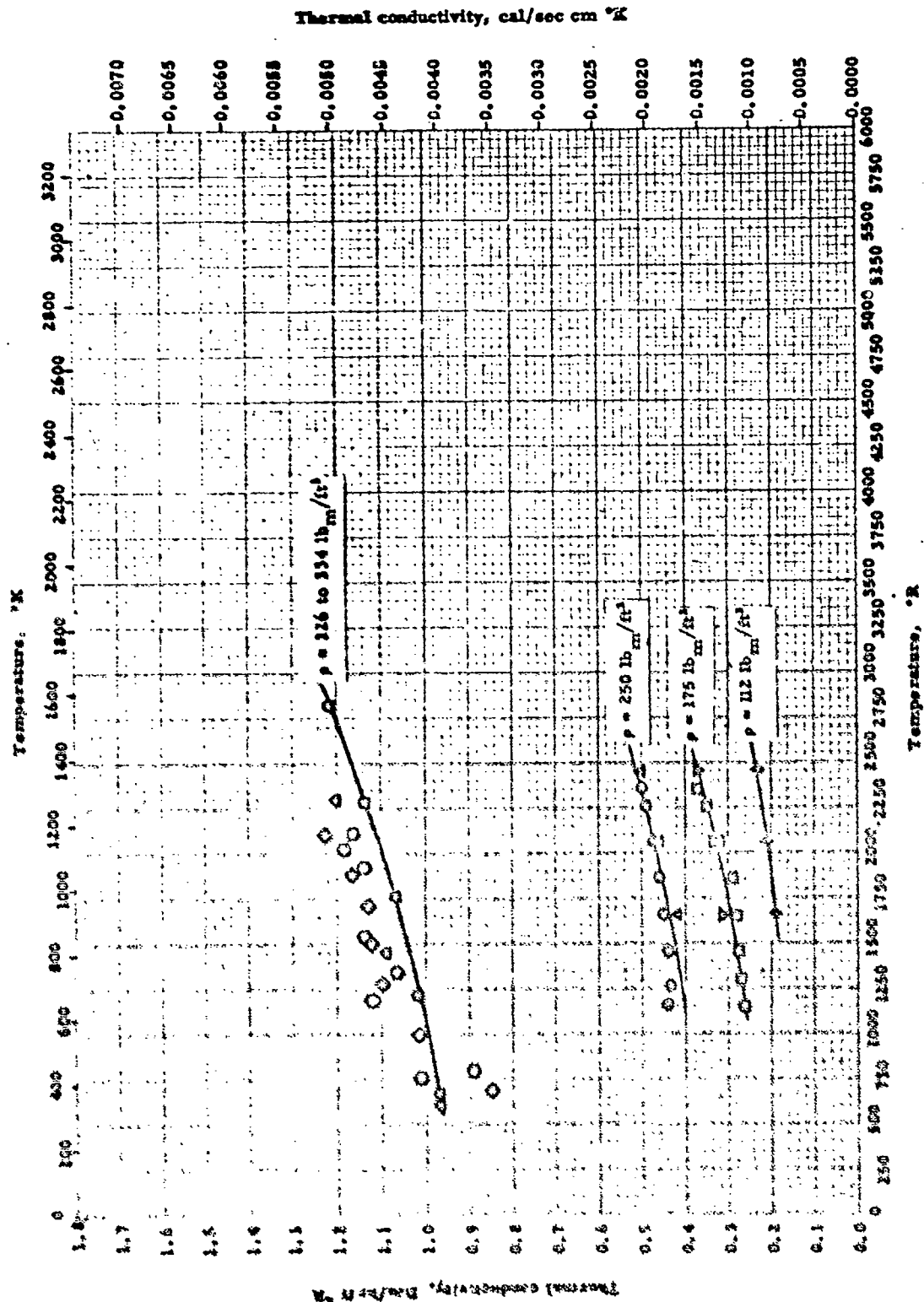


SPECIFIC HEAT - ZIRCONIUM OXIDE

SPECIFIC HEAT -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Coughlin, J. P. and King, E. G.	50-2	714-1315	ZrO ₂ : 1.25% H ₂ ; x-ray diffraction showed only monoclinic oxide	Drop method; copper block calorimeter	Auth. est. enthalpy data accurate within 0.2%
Δ	Arthur, J. L.	50-7	533-2278	ZrO ₂ . Analysis not given	Drop method; sample transferred manually from furnace to calorimeter	
□	Kelley, K. K.	44-2	98-532	99.1% ZrO ₂ ; 0.10% SiO ₂ ; 0.20% TiO ₂ ; 0.07% CaO; no other oxides > 0.05%	Guarded sample	Correction made for principal impurities (do not exceed 0.54%); Auth. est. accuracy ± 0.3%



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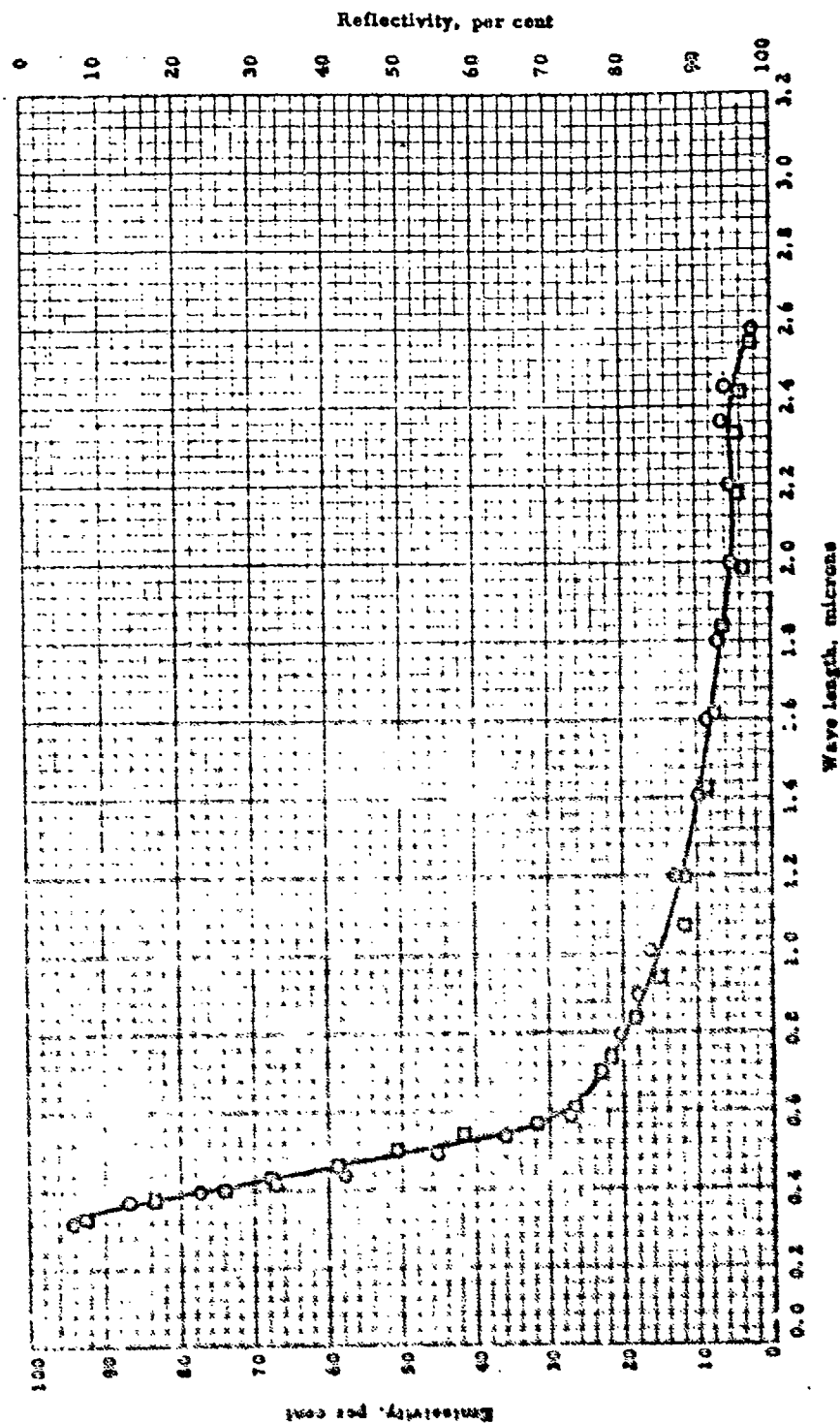
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THERMAL CONDUCTIVITY -- ZIRCONIUM OXIDE + X

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
1	Adams, M.	14-5	672-2334	$\rho = 224 - 334 \text{ lb}_m/\text{ft}^3$; porosity = 7.76 - 10.0%	Prolate spheroid envelope	Slip cast from suspension of finely ground material
2	Jones, M. C.	22-9	1660-2460	Stabilized: 94 - 95% ZrO_2 ; 4 - 5% CaO ; 0.14 - 0.75% SiO_2 ; 0.1 - 0.7% Fe_2O_3 ; 0.22 - 1.0% TiO_2 ; porosity = 25%	Not given	
3	E. A.	22-9	1660-2460	Same as above; porosity = 51%	Same as above	
4	E. A.	22-9	1660-2460	Same as above; porosity = 65%	Same as above	
5	Walters, Jr., O. J.	49-1	1160-2360	95% ZrO_2 + CaO ; stabilized zirconia mix No. 145-A; density $\rho = 250 \text{ lb}_m/\text{ft}^3$; Total porosity = 23%; apparent porosity = 26%	Single flat plate; liquid calorimeter	Made from 14 mesh grain or finer. Fired at 3230°F
6	Walters, Jr., O. J.	49-1	1160-2360	95% ZrO_2 + CaO ; stabilized zirconia mix No. 147; $\rho = 175 \text{ lb}_m/\text{ft}^3$; Total porosity = 50%; apparent porosity = 44%	Single flat plate; liquid calorimeter	Made from 8 mesh grain or finer. Fired at 3230°F
7	Martus, T. H. et al.	51-16	700-2100	Stabilized; $\rho = 226 \text{ lb}_m/\text{ft}^3$; total porosity = 2.37%	Not given	
8	E. A.	51-76	700-2100	Stabilized; $\rho = 224 \text{ lb}_m/\text{ft}^3$; total porosity = 4.74%	Not given	
9	Mortan, P. H.	51-77	620-2300	Stabilized; ZrO_2	Ellipsoidal envelope	Plotted values are auth. average with in $\pm 20\%$

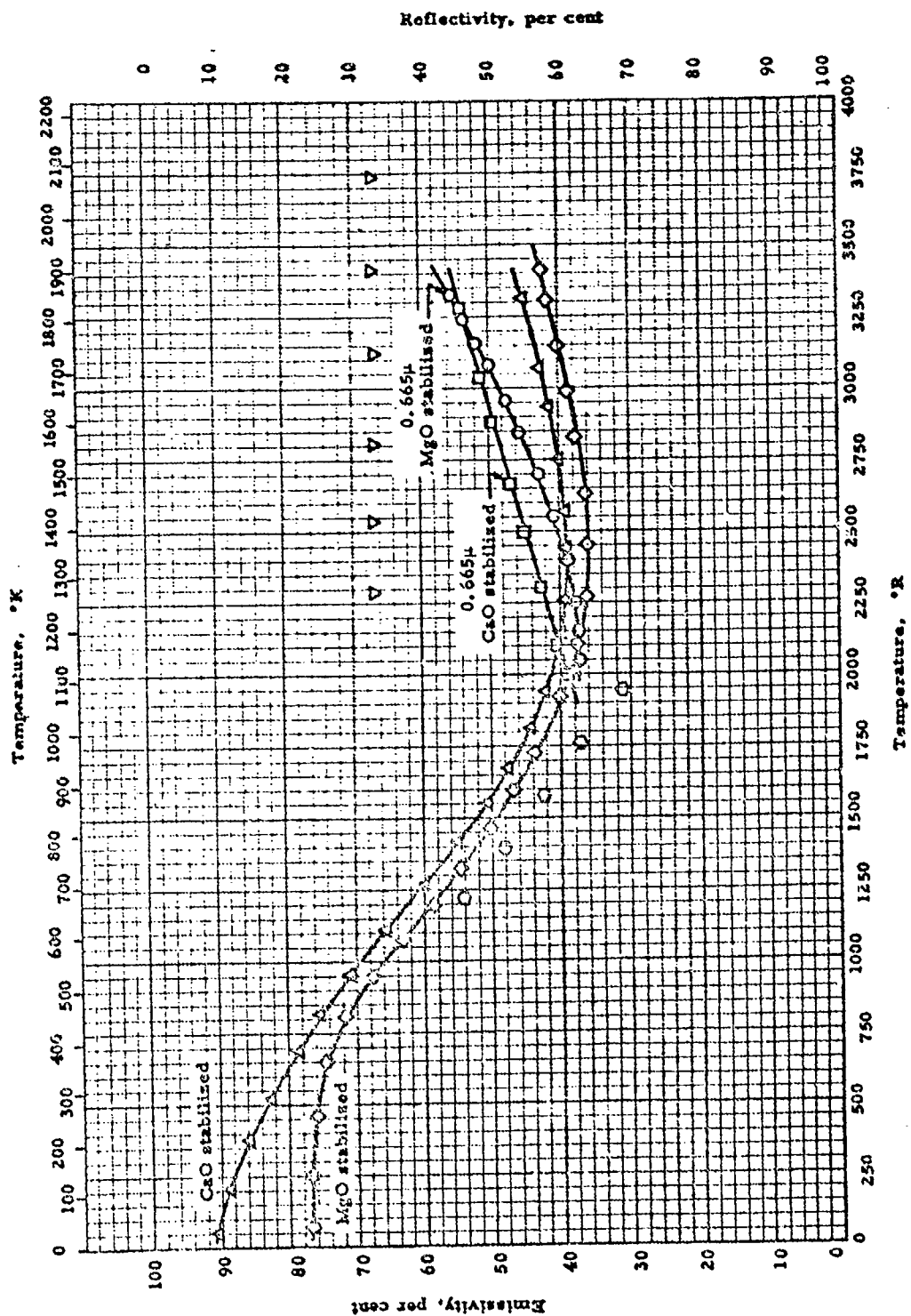


SPECTRAL EMISSIVITY -- ZIRCONIUM OXIDE, STABILIZED

SPECTRAL EMISSIVITY -- ZIRCONIUM OXIDE, STABILIZED

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
59-1	Olson, O. H. and Morris, J. C.	Room	Zirconium oxide, calcium stabilized	Spectral reflectivity at 9°, sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detec- tor	
59-1	Ibid.	Room	Zirconium oxide, magnesium stabilized	Same as above	



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EMISSION -- ZIRCONIUM OXIDE + X

EMISSIVITY -- ZIRCONIUM OXIDE + X

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
59-1	Dixon, O. H. and Morris, J. C.	59-1	1960-3260	Zirconium Oxide, magnesium stabilized	Normal spectral emissivity at 0.665 μ ; meas. apparent transmissivity through sample from black body at same temp sample temp. by thermocouple, disappearing filament optical pyrometer	Sample in furnace, in air. Auth. est. accuracy $\pm 3\%$
59-2	Ibid.	59-2	1960-3260	Zirconium oxide, calcium stabilized	Same as above	
59-1	Ibid.	59-1	160-3160	Same as above	Total normal emissivity; comparative, surface brightness compared with that of a black body hole, using thermopile. Temp. by thermocouple	
59-1	Ibid.	59-1	160-3160	Zirconium oxide, magnesium stabilized	Same as above	Same as above
57-164	Lemmon Jr., A. W., Wood, W. D. et al.	57-164	2292-3732	Zirconia	Total normal emissivity; comparative, surface brightness compared with that of a standard (graphite). Temp. by brightness temp. of graphite in vacuum	
52-81	Sully, A. H., Brandes, E. A. and Waterhouse, R. E.	52-81	1212-1932	"Pure" zirconia	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated Pt-Pt Rh thermocouple	Calibrated Pt-Pt Rh thermocouple calibrated at MP of Sn, Sb, Al, Ag to within $\pm 0.5^\circ\text{C}$

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + BERYLLIUM OXIDE + ALUMINUM OXIDE

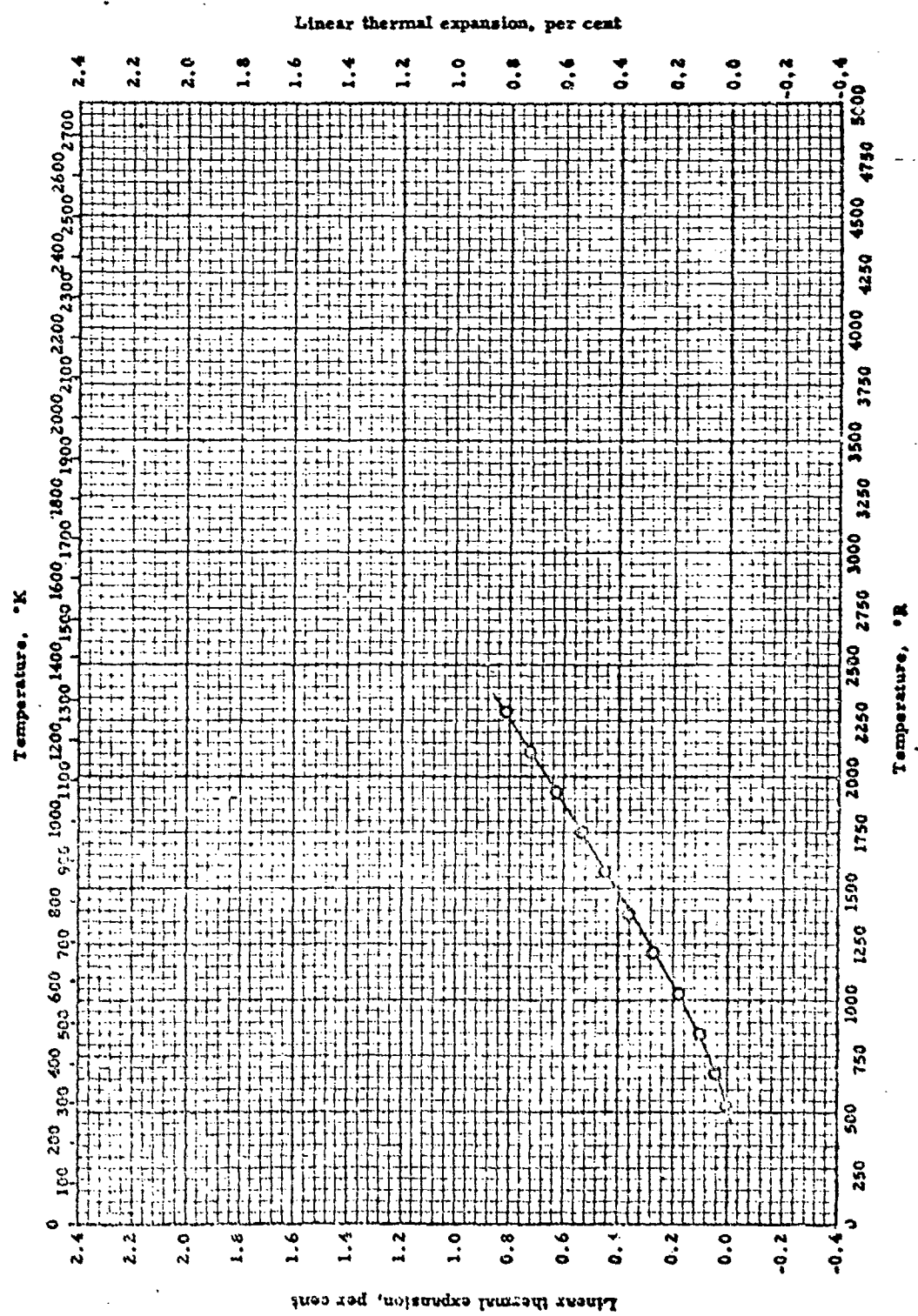
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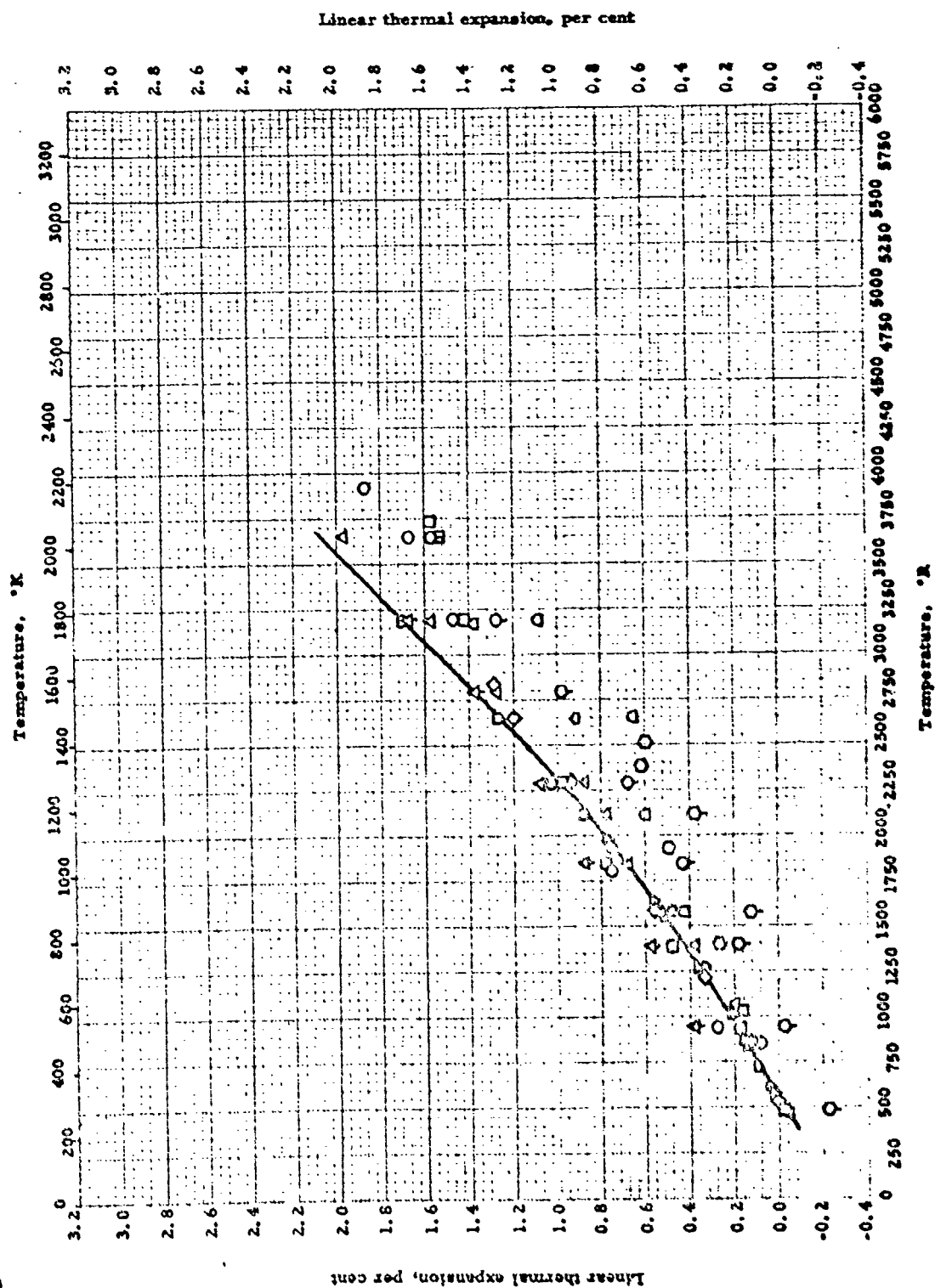
Sym b-1	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	44.92% ZrO ₂ ; 36.48% BeO; 18.59% Al ₂ O ₃ ; prepared from 99.7% pure BeO, 99.4% pure Al ₂ O ₃ , C.P. ZrO ₂ (calcined)	Interferometer	8BeO · Al ₂ O ₃ · 2ZrO ₂

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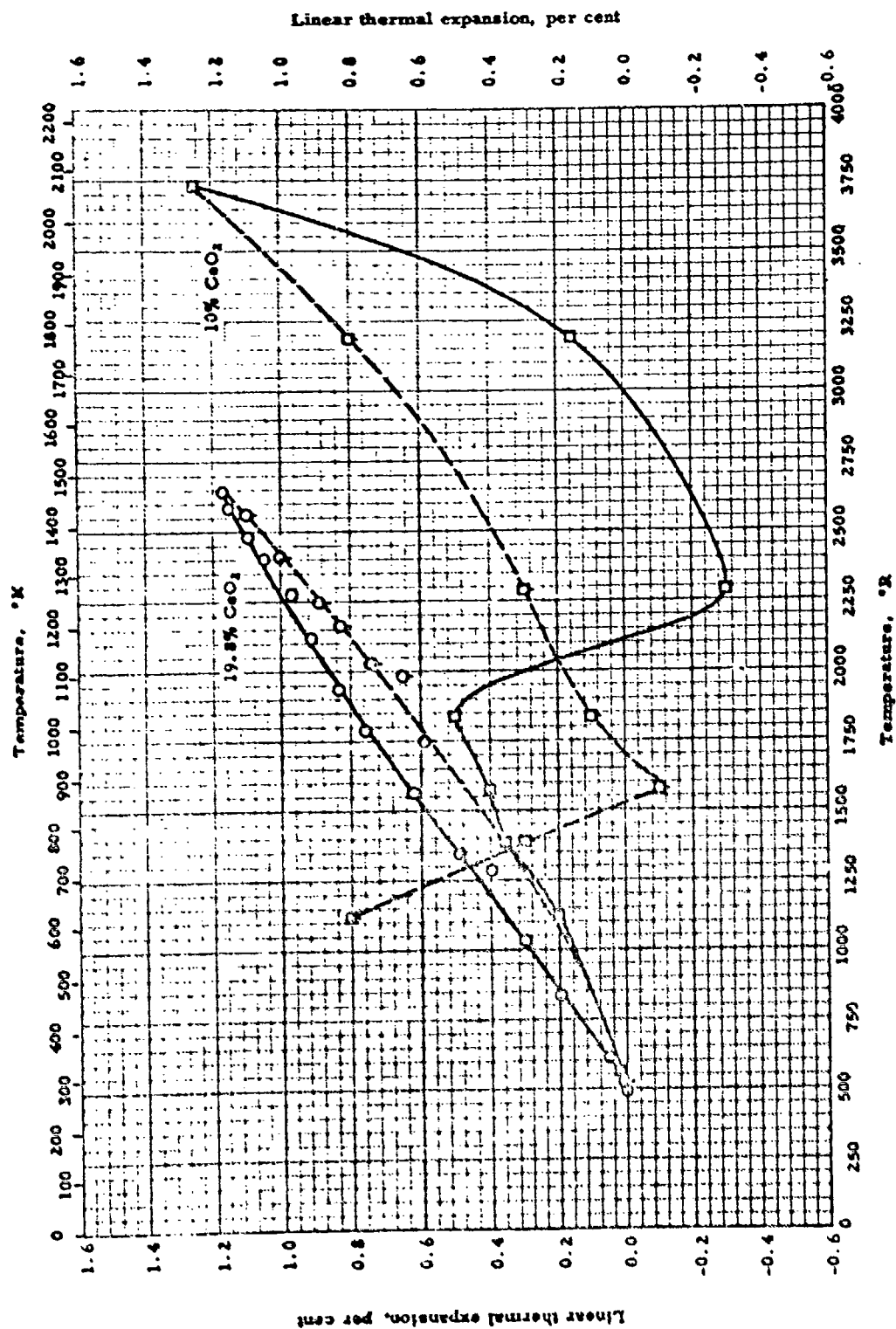


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CALCIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
49-17	Pierrey, J.	492-3912	97% ZrO ₂ ; 3% CaO	Optical comparator sighting on pointed ends of sample	Melted in solar furnace O-heating; Q-cooling
49-17	Ibid.	492-3732	97% ZrO ₂ ; 3% CaO	Same as above	Melted in electric arc, broken up, consolidated and baked at 2200°C
49-17	Ibid.	492-3642	69% ZrO ₂ ; 31% CaO	Same as above	Δ-heating; Δ-cooling
52-11	Schwartz, B.	531-2832	ZrO ₂ with < 1% impurities; stabilized with 4% CaO	Telemicroscopes sighting on 6 in. sample	Slip cast, dried, fired at 1150°C, machined, matured 3 hr. at 1830°C. Tested at 4°C/min. rise
55-58	Mauer, F.A. and Bols, L. H.	492-1975	92.25% ZrO ₂ ; 7.71% CaO; cubic phase only, prepared from c.p. raw materials	X-ray diffraction	Tested in He atmos.
56-64	Uel, L. et al	528-2510	85.28% ZrO ₂ ; 10% CaO; 3.11% SiO ₂ ; 1.15% (Al ₂ O ₃ + Fe ₂ O ₃ + TiO ₂)	Silica glass dilatometer	Calcined ZrO ₂ (250 mesh) with 10% CaO at 1600°C for 2 hrs., dry pressed at 12,000 psi and fired 2 hrs. at 1600°C. Auth. also report data for 2-10% CaO; 3-4% SiO ₂ ; 1.2-4% other oxides
56-7	Whittemore, O.J., and Ault, M.N.	1032-3192	Coarse fused, stabilized	Telemicroscopes sighting on ends of sample	Two samples. Probably calcia stabilized
56-7	Ibid.	1032-3192	100% cubic, fused	Same as above	Same as above
50-10	Gangler, J.J.	540-1560	Stabilized; 0.16% combined C; < 0.01% free C; apparent ρ = 362 lb./ft. ³	Interferometer	Probably calcia stabilized. Hot pressed in graphite mold; tested at 4°C/min. rise

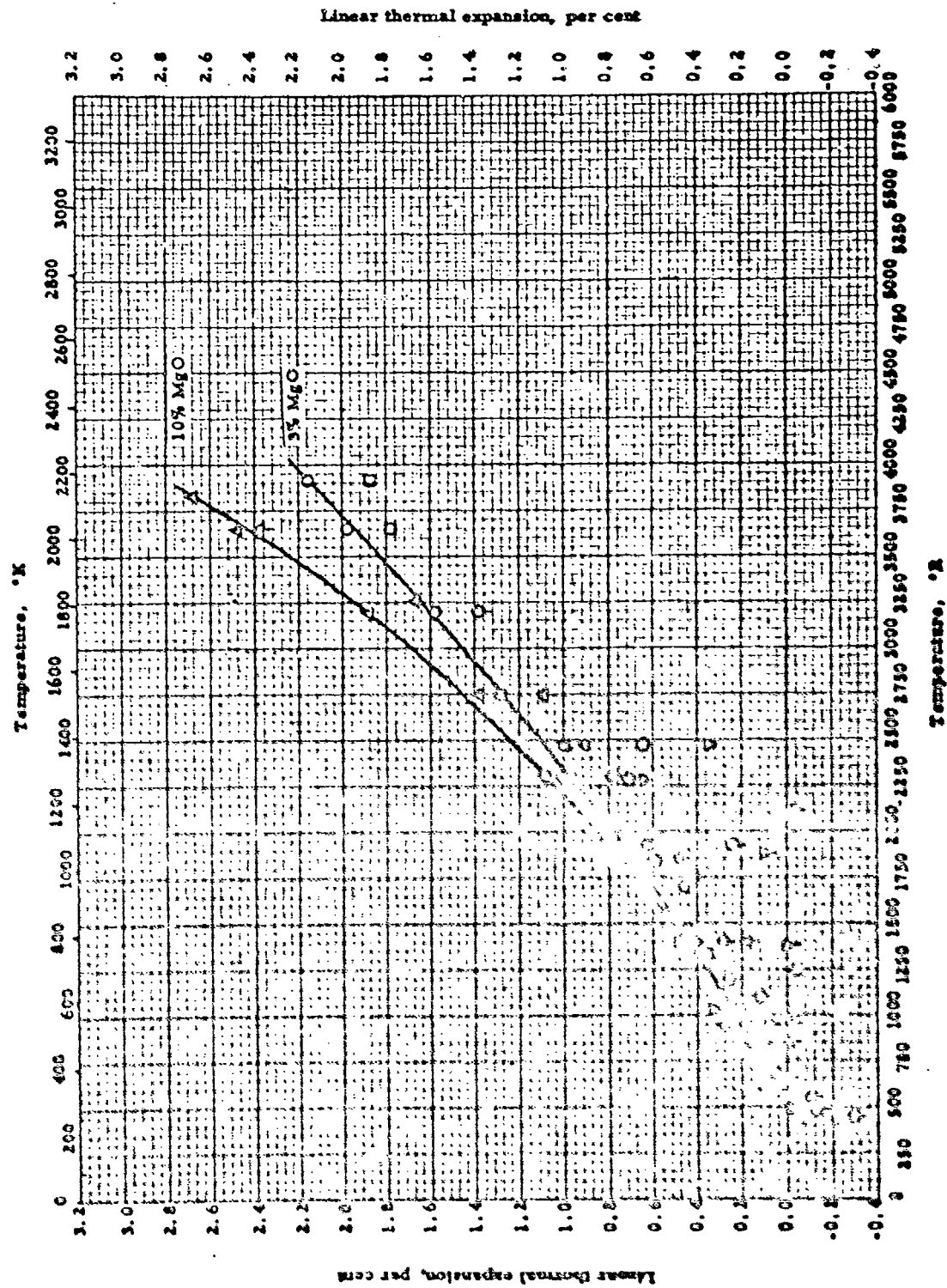


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CERIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CERIUM OXIDE

REFERENCE INFORMATION

Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Mayer, F. A. and Bols, L. H.	56-8	492-2647	80.2% ZrO ₂ ; 19.8% CeO ₂	Dilatometer	X-ray analysis showed 75% tetragonal (soln. of CeO ₂ in ZrO ₂) and 20% monoclinic (not enough CeO ₂ to suppress transf.); the rest unmodified cubic CeO ₂ O -heating Q -cooling
Q	Pierrey, J.	49-17	492-3732	90% zirconia; 10% ceria. $\rho = 501 \text{ lb}_{\text{m}}/\text{ft}^3$	Observation of ends of bar with optical comparator. Temp. by two methods: a. <1000°C: Chromel-Alumel thermocouple b. >1000°C: optical pyrometer	Baked at 2100°C Q -heating Q -cooling



LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

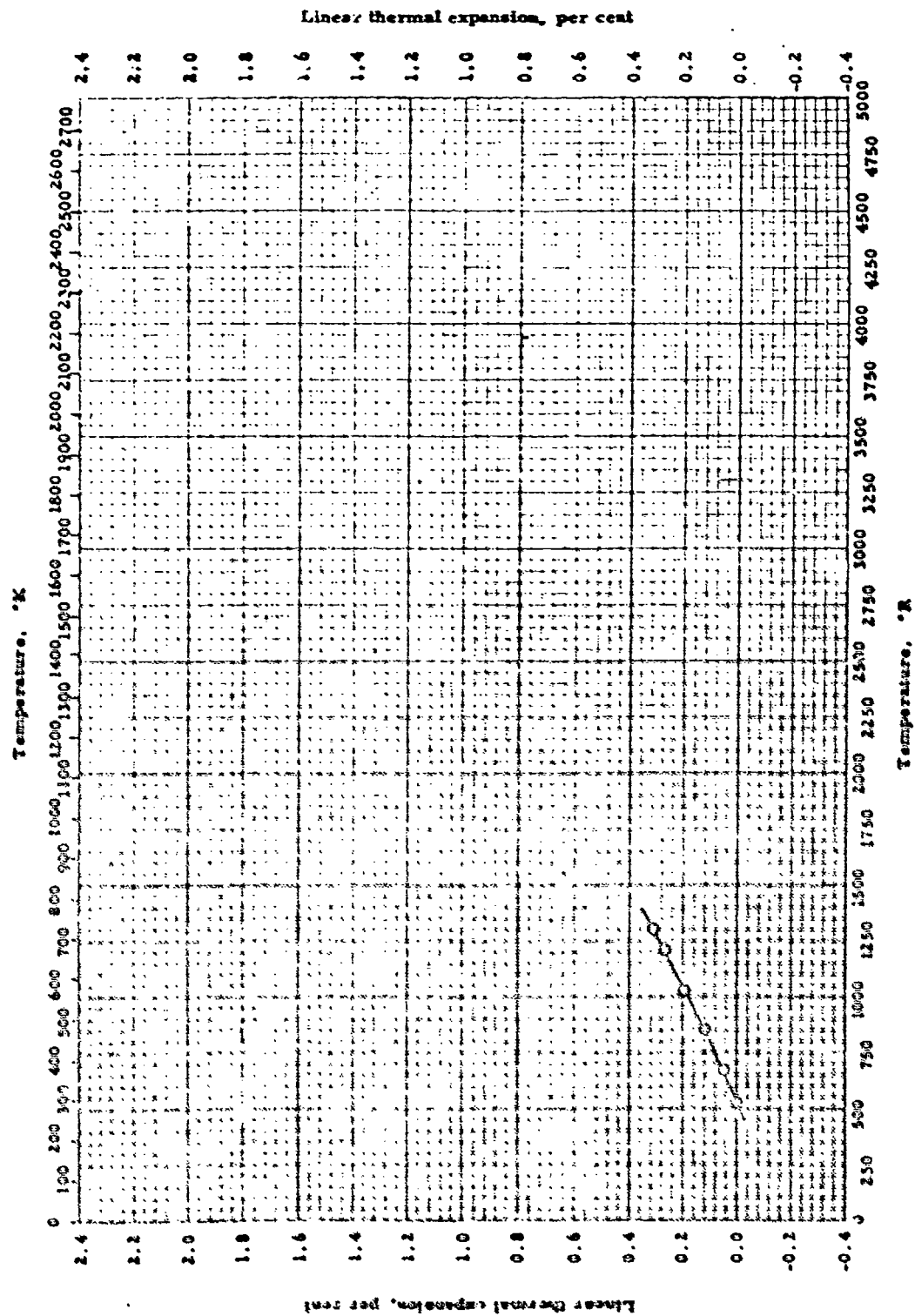
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pierrey, J.	49-17	492-3912	97% ZrO ₂ ; 3% MgO; prepared from 99+ pure ZrO ₂ and precipitated MgO	Optical comparator sighting on pointed ends of sample	Melted in solar furnace ○ - heating; □ - cooling
□	Ibid.	49-17	492-3912	Same as above	Same as above	Mixed; sintered at 2200°C
△	Ibid.	49-17	492-3822	99% ZrO ₂ ; 10% MgO; raw materials same as above	Same as above	Mixed; sintered at 2200°C △ - heating; □ - cooling
◇	Mawer, F. A. and Bols, L. H.	54-37	672-2292	94.34% ZrO ₂ ; 5.66% MgO; cubic	X-ray diffraction	Measured rapidly in high temp. region to reduce reversion to monoclinic type
▽	Uel, I. et al.	56-64	528-2472	97.61% ZrO ₂ ; 2% MgO; 0.20% SiO ₂	Silica glass dilatometer	Calcined 250-mesh ZrO ₂ powder with MgO at 1600°C for 2 hr.; dry pressed at 1 ton/cm ² ; fired 2 hr. at 1600°C. ▽ - heating, Y - cooling
○	Ibid.	56-64	528-2472	95.62% ZrO ₂ ; 4% MgO; 0.19% SiO ₂	Same as above	Same as above ○ - heating, □ - cooling
□	Ibid.	56-64	528-2472	93.62% ZrO ₂ ; 6% MgO; 0.19% SiO ₂	Same as above	Same as above □ - heating, □ - cooling
◇	Ibid.	56-64	528-2472	91.62% ZrO ₂ ; 8% MgO; 0.18% SiO ₂	Same as above	Same as above ◇ - heating, ◇ - cooling. Auth. also reports data for mat. 2-12% MgO; 3% SiO ₂ ; 1.14% other oxides

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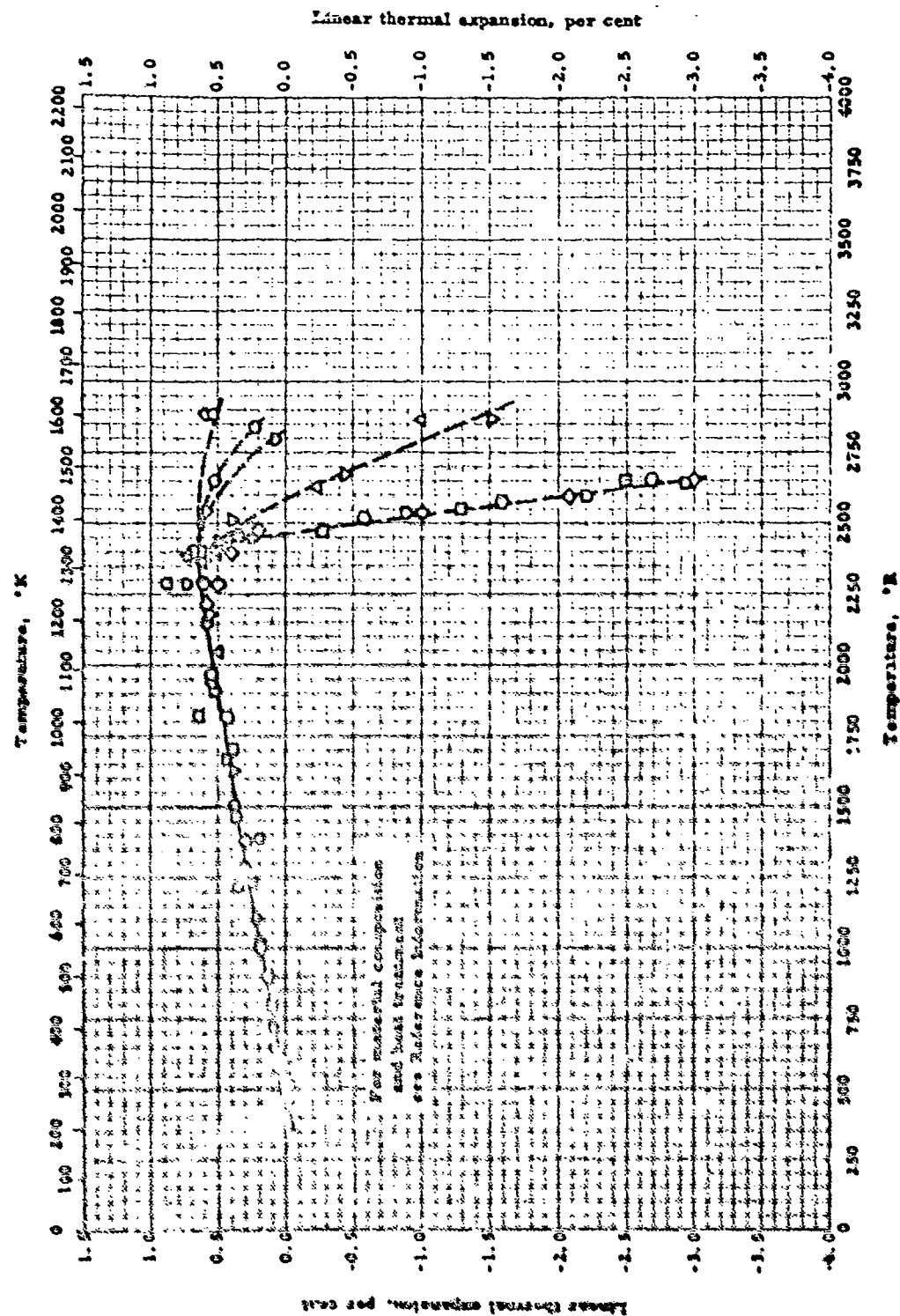


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + NIOBIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + NIOBIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O Carlitz, E. A. and Hartman, C. G.	32-31	928-1302	70.8% ZrO ₂ ; 29.2% Nb ₂ O ₅ Solid solution (32ZrO ₂ + Nb ₂ O ₅)	Interferometer	Fired 2 hr. at 1485°C; cooled over 24 hr. period

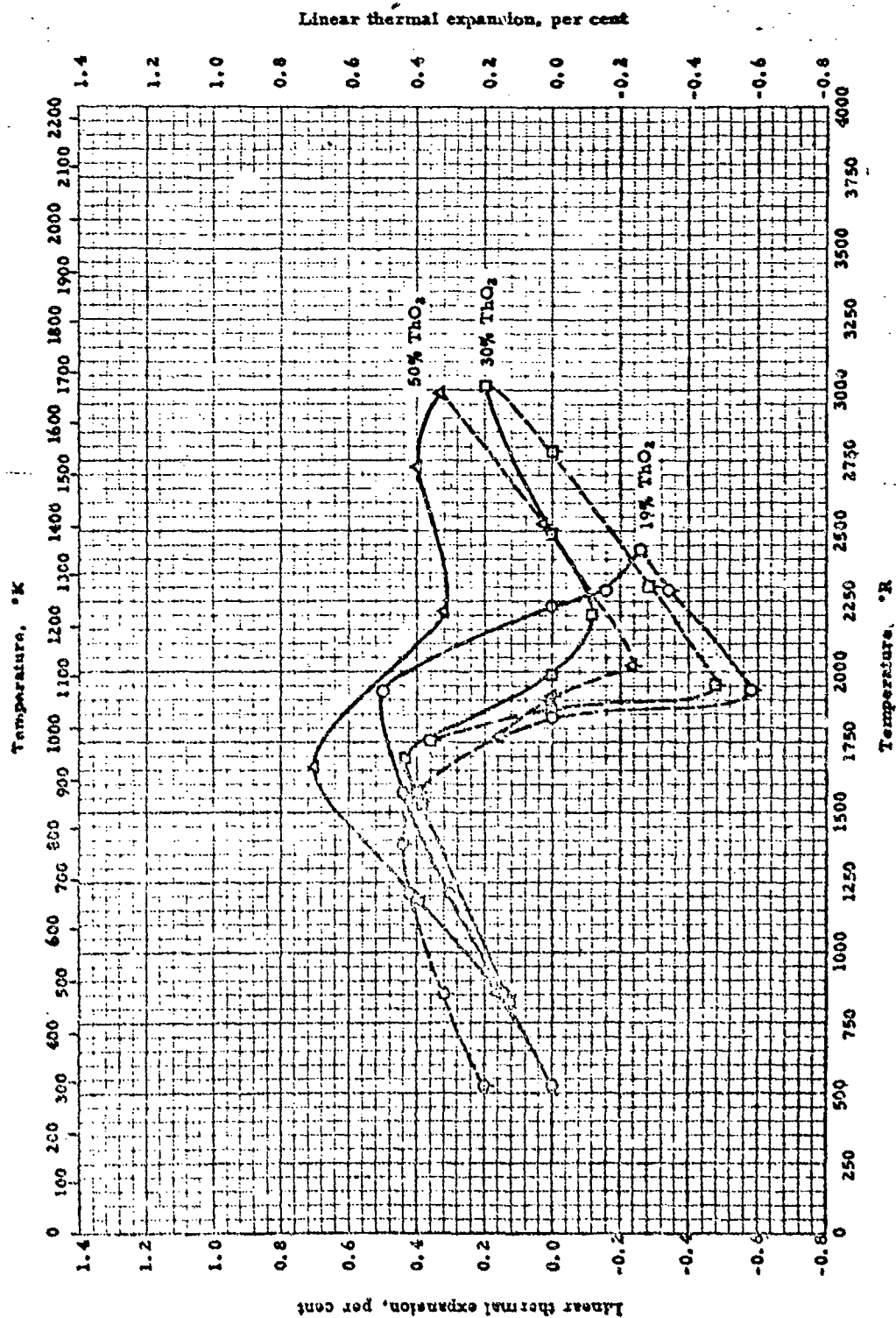


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + SILICON OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
12	Thurston, W. R., Richart, W. R. et al.	52-433	519-2652	ZrO ₂	Not given	Heated 3 hr. at 1000°C
A	Ed.	52-433	519-2858	Same as above	Same as above	Heated 3 hr. at 1150°C
O	Ed.	52-433	519-2652	99 mole % ZrO ₂ ; 1 mole % SiO ₂	Same as above	Heated 3 hr. at 1000°C
V	Ed.	52-433	519-2858	Same as above	Same as above	Heated 3 hr. at 1150°C
O	Ed.	52-433	519-2652	90 mole % ZrO ₂ ; 10 mole % SiO ₂	Same as above	Heated 3 hr. at 1000°C
O	Ed.	52-433	519-2856	Same as above	Same as above	Heated 3 hr. at 1150°C
O	Ed.	52-433	519-2856	Same as above	Same as above	Heated 3 hr. at 1350°C
O	Ed.	52-433	519-2652	80 mole % ZrO ₂ ; 20 mole % SiO ₂	Same as above	Heated 3 hr. at 1000°C
O	Ed.	52-433	519-2796	Same as above	Same as above	Heated 3 hr. at 1150°C
O	Ed.	52-433	519-2832	Same as above	Same as above	Heated 3 hr. at 1350°C

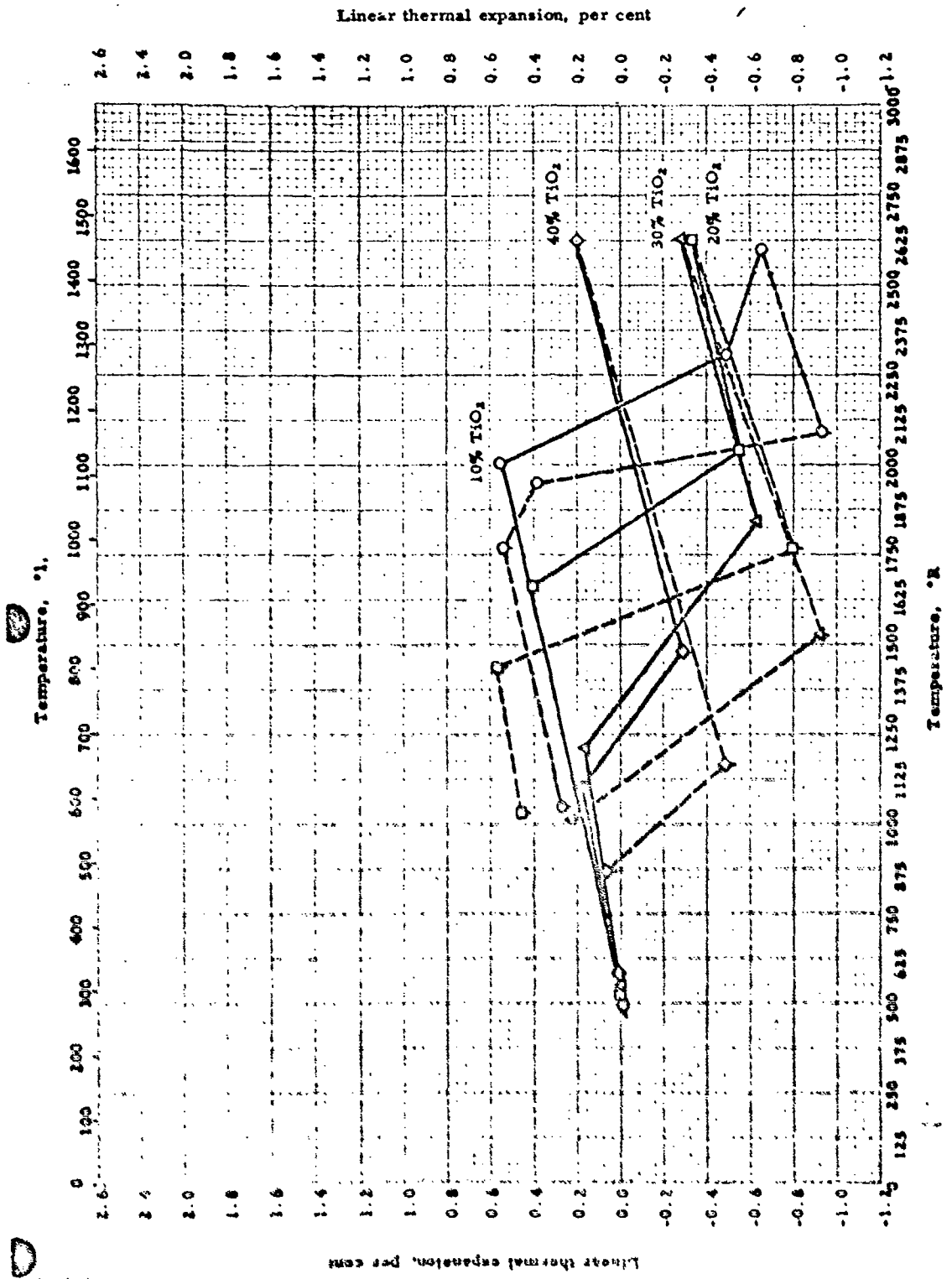


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + THORIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + THORIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Temp., °C	Material Composition	Test Method	Remarks
○	Davis, P. and Leh, E.	57-193	528-2436	81.76% ZrO ₂ ; 19.24% ThO ₂	Dial gauge	ZrO ₂ 99.7% pure and ThO ₂ 99.4% pure were sintered at 1350°C ○ -heating ○ -cooling
□	Somiya, E.; Yamauchi, T. and Suzuki, H.	57-93	852-3012	70% ZrO ₂ ; 30% ThO ₂	Dial gauge. Temp. by Pt, Pt-Rh thermocouple	ZrO ₂ analysis: 97.8% ZrO ₂ ; 0.57% SiO ₂ ; 0.40% H ₂ O; 0.23% TiO ₂ ; 0.16% Fe ₂ O ₃ ; 1.61% ignition loss, trace MgO and CaO. Component dry mixed in agate mortar, 5% dextro- lyne added as binder, pressed at 1000 kg/cm ² , fired to 1700°C in 5-1/2 hr., soaked 1 hr., cooled overnight. Heated to 1000°C at 10°C/min, 1000- 1400°C at 7°C/min. Cooled to 800°C at 10°C/ min., then to room temp. naturally □ -heating □ -cooling
△	Ind.	57-93	852-2994	50% ZrO ₂ ; 50% ThO ₂	Same as above	Same as above, △ -heating △ -cooling

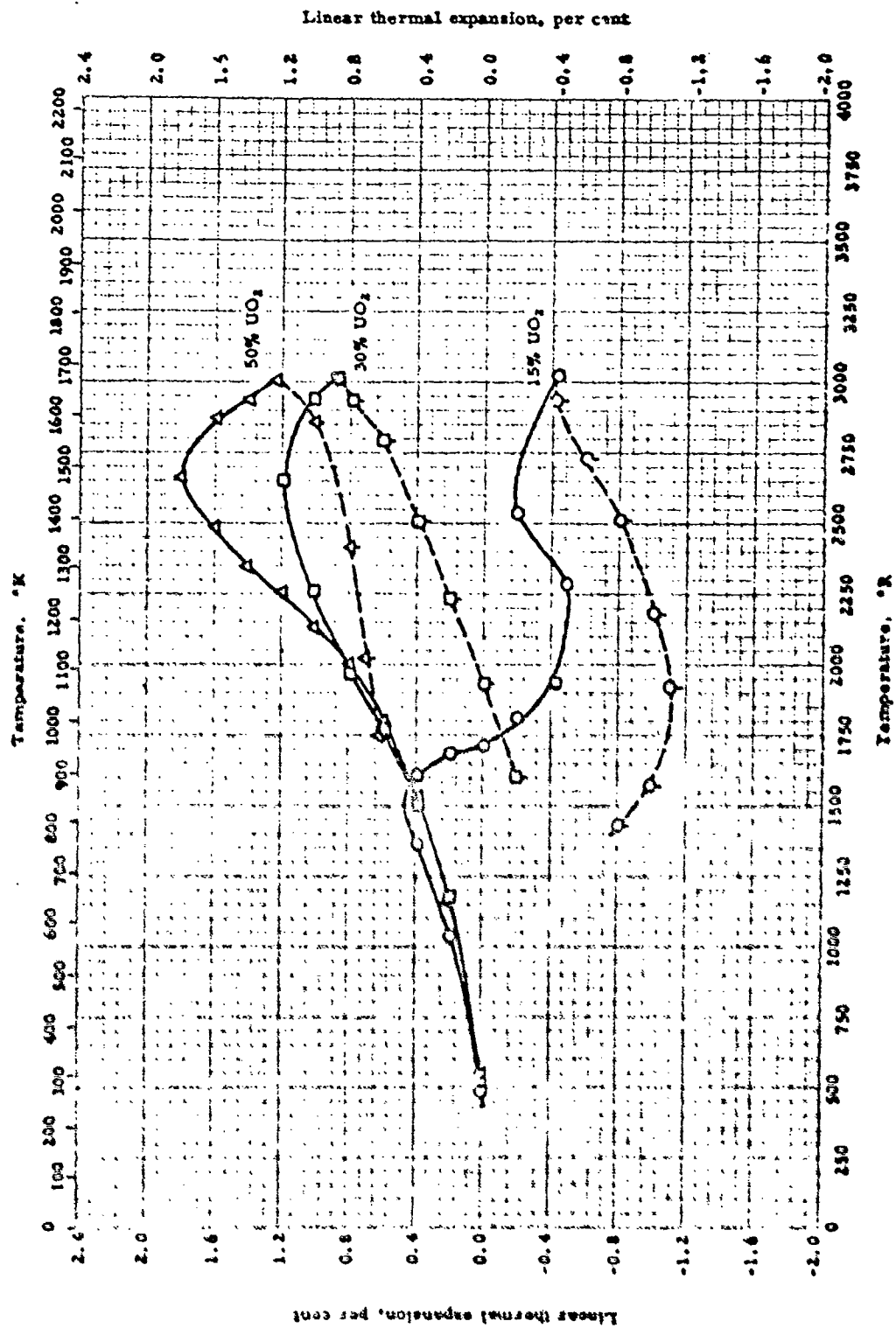


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Drown Jr., F. H. and Duvos, P.	54-147	492-2598	90% ZrO ₂ ; 10% TiO ₂	Automatic recording dilatometer. Heating rate 220°C/hr; cooling rate 315°C/hr.	Mixed from 99% pure ZrO ₂ and c.p. anatase, pressed at 15,000 psi, fired 2 hr. at 1760°C in oxidizing atm., 316 hr. at 1370°C, and 1465 hr. at 980°C, both in air ○ - heating □ - cooling
□	Did.	54-147	492-2652	80% ZrO ₂ ; 20% TiO ₂	Same as above	Same as above □ - heating □ - cooling
△	Did.	54-147	492-2652	70% ZrO ₂ ; 30% TiO ₂	Same as above	△ - heating △ - cooling
◇	Did.	54-147	492-2652	60% ZrO ₂ ; 40% TiO ₂	Same as above	◇ - heating ◇ - cooling

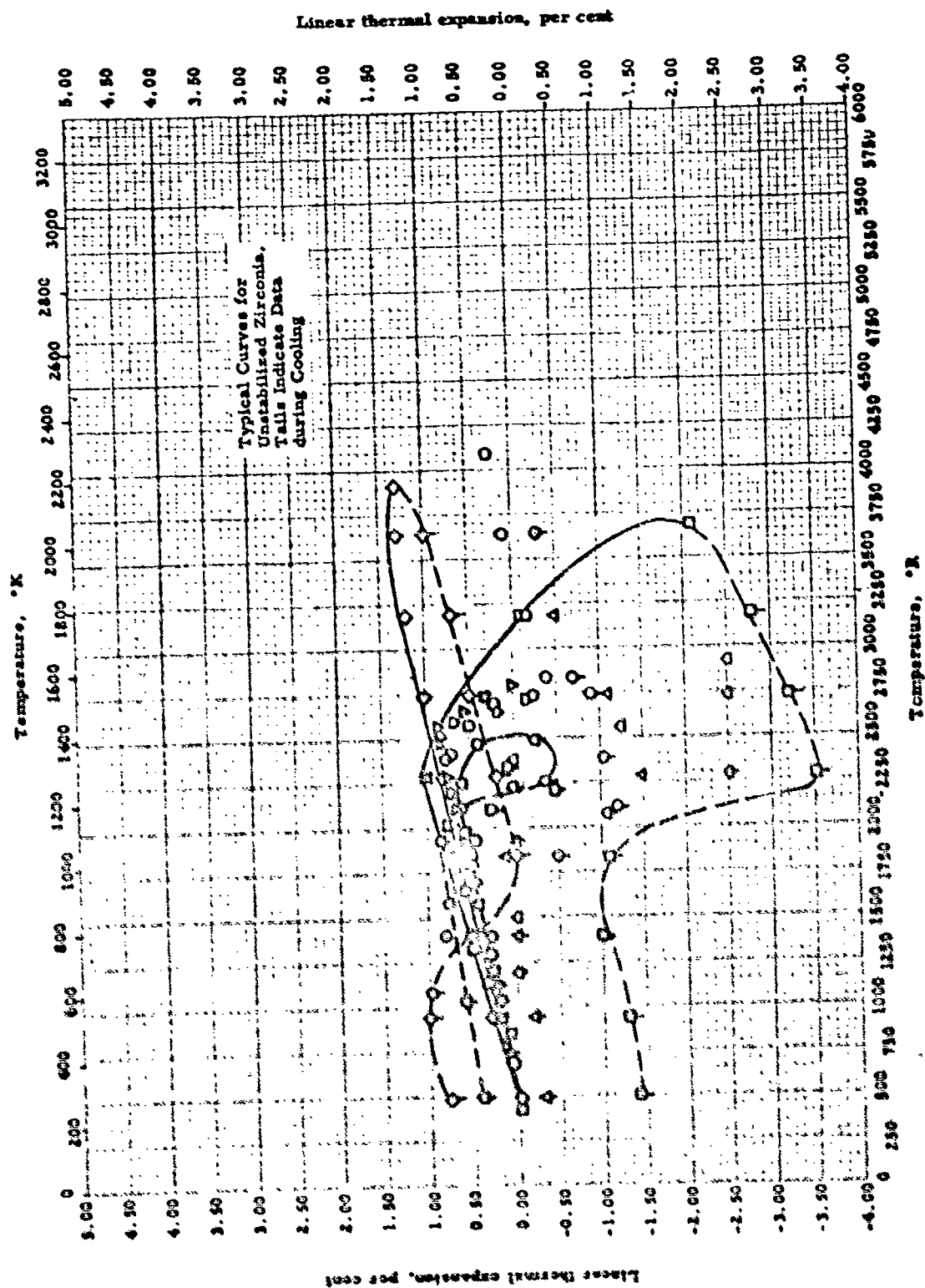


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + URANIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

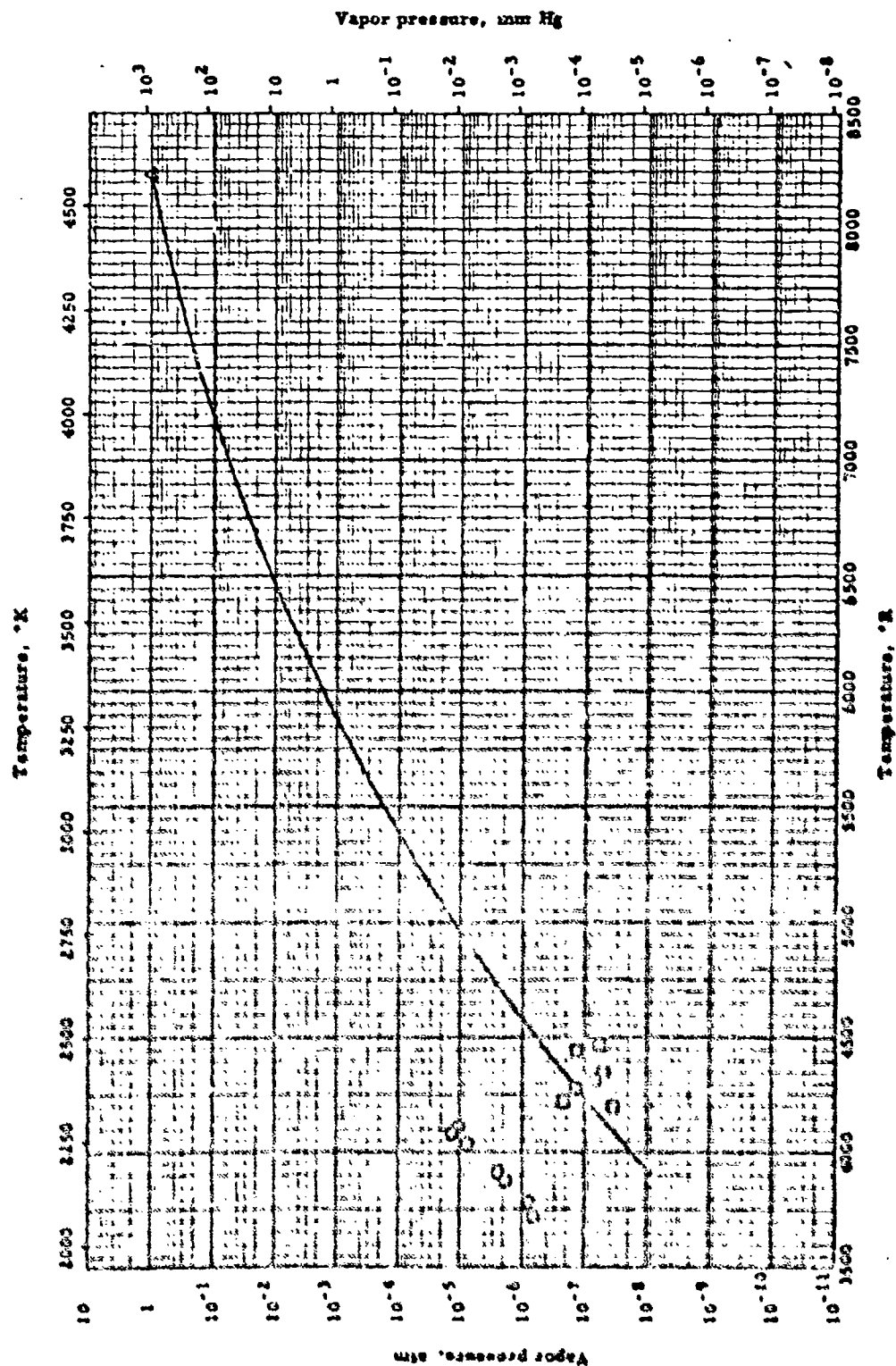
Symbol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	G. M. Y. S. S., Yamashita, T. and Suzuki, H.	57-93	492-3012	85% ZrO ₂ ; 15% UO ₂	Dial gauge; temp. by Pt, Pt-Rh thermocouple	ZrO ₂ analysis: 97.0% ZrO ₂ , 0.57% SiO ₂ , 0.40% H ₂ O, 0.23% TiO ₂ , 0.16% Fe ₂ O ₃ , 1.61% ignition loss, trace MgO and CaO. UO ₂ from heating U ₃ O ₈ 1 hr. at 650°C in H ₂ atm. Components dry mixed in agate mortar, 5% dextro- lyne added as binder, pressed at 1000 kg/cm ² , fired to 1700°C in 3-1/2 hr. soaked 1 hr., cooled over- night. Heated to 1000°C at 10°C/min. 1000-1400°C at 7°C/min. Cooled to 800°C at 10°C/min. then to room temp. naturally. O - heating Q - cooling
Q	Isid.	57-93	492-3012	70% ZrO ₂ ; 30% UO ₂	Same as above	Same as above, O - heating Q - cooling
Δ	Isid.	57-93	492-3012	50% ZrO ₂ ; 50% UO ₂	Same as above	Same as above, Δ - heating Q - cooling



LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
49-17	Piarray, J.	49-17	492-492	Approx. 1% H ₂ O ₂ ; $\rho = 337 \text{ lb}_m/\text{ft}^3$	Optical comparator sighting on pointed ends of sample	Fired at 1400°C, molded under pressure, and heated 15 min. at 2200°C in air stream
49-17	Ibid.	49-17	492-3687	99% ZrO ₂ ; 1% BeO of 99% purity; $\rho = 305 \text{ lb}_m/\text{ft}^3$	Same as above	Precipitated from solution, washed, dried, compression molded and baked at 2200°C. 2 samples
49-17	Ibid.	49-17	492-3912	"Pure"; $\rho = 341 \text{ lb}_m/\text{ft}^3$	Same as above	Melted in arc furnace, cast, finely broken, molded under pressure and heated 15 min. at 2100°C in air
54-45 also 54-46	Curtis, C. E., Dancy, L. M., and Johnson, J. R.	54-45	672-2832	0.06% Fe; 0.02% Si; 0.015% Al; 0.003% H ₂ ; 0.006% Ti	Calibrated differential dilatometer; sapphire push rod	Ground to pass 325 mesh screen, pressed at 20,000 psi with 5% water and 2% dextrin, fired in oxyacetylene furnace 2 hr. at 1600°C
49-16	Trombe, F.	49-16	528-1932	97.7% pure	Not given	Cast
54-64	Uel, L. et al.	54-64	528-2490	99.6% ZrO ₂ ; 0.2% SiO ₂ ; trace of Al ₂ O ₃ ; Zr ₂ O ₃ ; TiO ₂ ; $\rho = 362 \text{ lb}_m/\text{ft}^3$	Silica glass dilatometer	Calcined 2 hr. at 1600°C; ground to 250 mesh, dry pressed (1 ton/cm ²); fired 2 hr. at 1600°C. Auth. also reports data for ZrO ₂ with 3 - 7% SiO ₂ and up to 1.64% other oxides
57-193	Kuznetsov, A. K.	57-193	492-2292	ZrO ₂	Not described here. refers to others	Q - heating, Q - cooling
54-147	Brown, Jr., F. H. and Daves, P.	54-147	528-2688	ZrO ₂ ; 99% pure	Automatic recording dilatometer	Grade A Zircon of Nat'l Lead Co. Q - heating, Q - cooling



VAPOR PRESSURE -- ZIRCONIUM OXIDE

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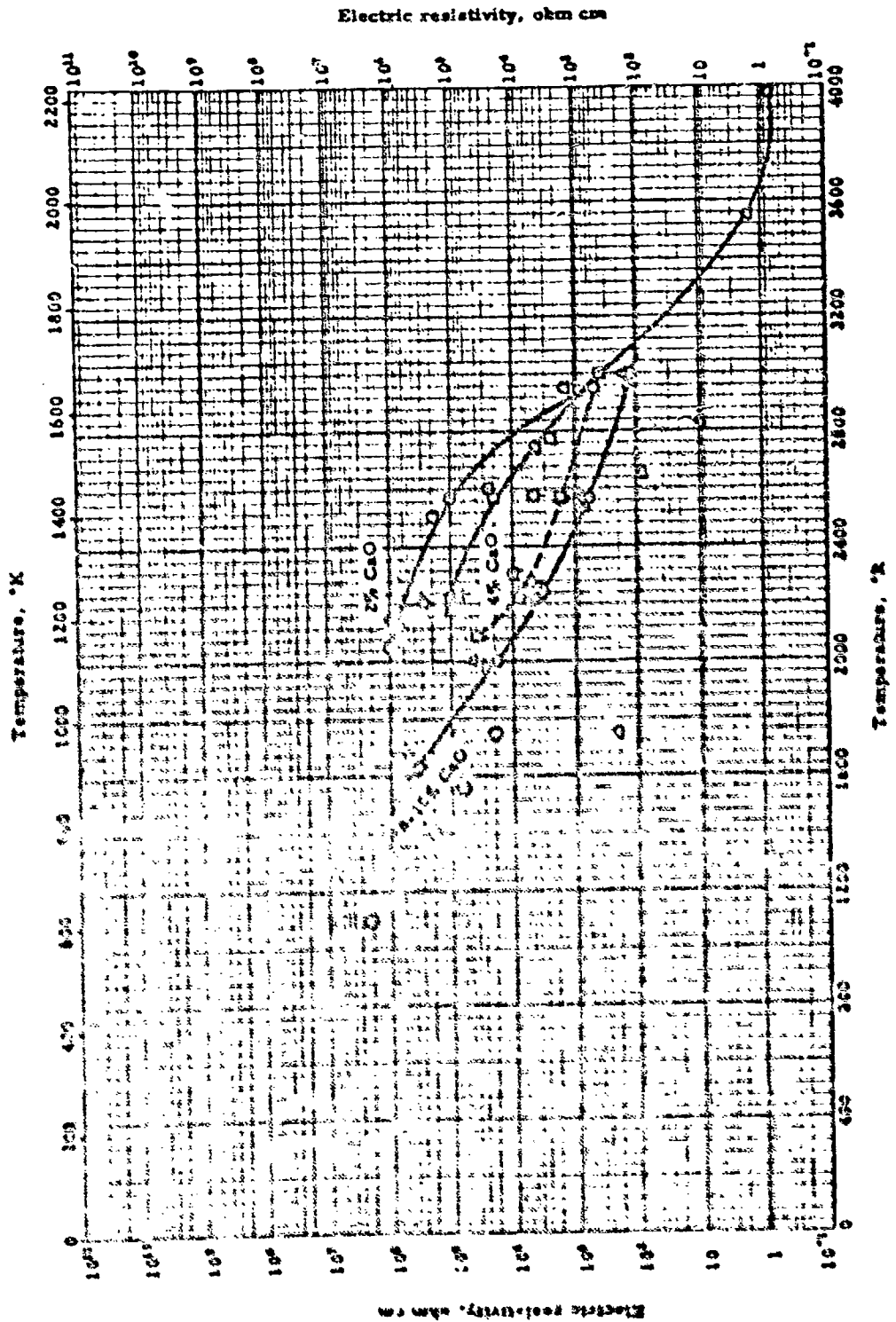
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VAPOR PRESSURE -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Hoch, M., Hakala, M., and Jounanen, M. L.	47-48 also 54-55	1713-1728	Zr O ₂ <0.013% Hf	Knudsen effusion cell	Ta cell
G	Chapka, W. A., Berkevis, J., and Legras, H. G.	ND-2	4194-4204	Zirconia. ZrO ₂	Knudsen effusion cell with mass spec. trom- eter	Ta cell
Δ	Trambo, F.	49-50	4211	ZrO ₂	Not given	

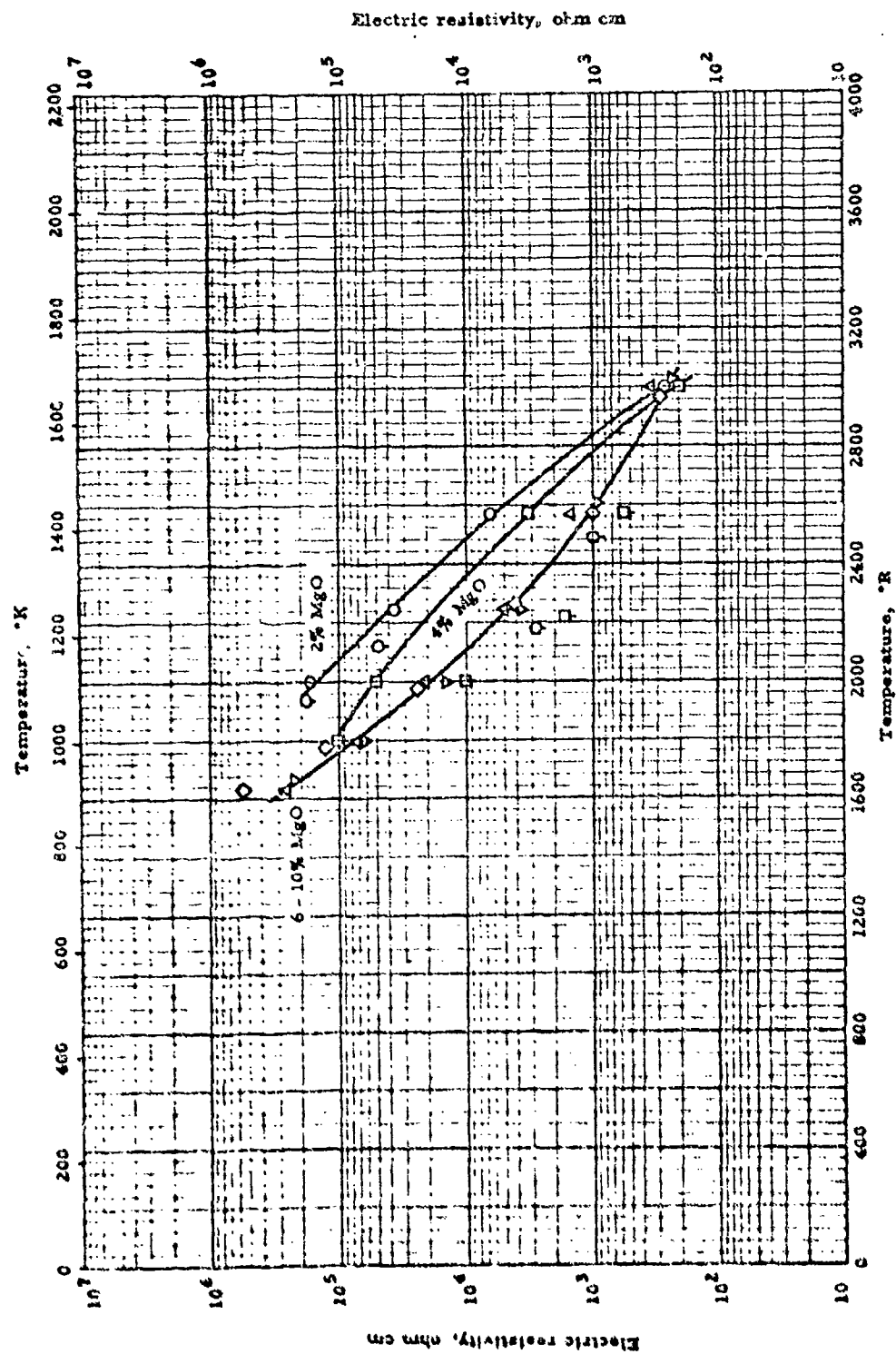


ELECTRIC RESISTIVITY -- ZIRCONIUM OXIDE + CALCIUM OXIDE

ELECTRIC RESISTIVITY -- ZIRCONIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, R	Material Composition	Test Method	Remarks
Uet, L., Matsuzawa, Y. and Uetaki, T.	56-64	2057-2951	97.61% ZrO ₂ ; 2% CaO; 0.20% SiO ₂	Not given	Made from ZrO ₂ with 0.20% SiO ₂ , trace Al ₂ O ₃ , Fe ₂ O ₃ , TiO ₂ , p = 362 lb _m /ft ³ Q - heating Q - cooling
Eis.	56-64	2093-3000	95.62% ZrO ₂ ; 4% CaO; 0.19% SiO ₂	Same as above	Same as above, Q - heating Q - cooling
Eis.	56-64	1698-3000	93.42% ZrO ₂ ; 6% CaO; 0.19% SiO ₂	Same as above	Same as above, but average of heating and cooling data
Eis.	56-64	1636-3000	91.62% ZrO ₂ ; 8% CaO; 0.18% SiO ₂	Same as above	Same as above
Eis.	56-64	1682-3060	89.64% ZrO ₂ ; 10% CaO; 0.18% SiO ₂	Same as above	Same as above
Zegener, H.	40-20	1104-1752	Not given	Potential drop; sample temp. by Pt-Rh thermocouple; voltage by electrometer	1 cm cube samples, platinised end faces. Auth. est accuracy order of magnitude only
Uet, L., Matsuzawa, Y. and Uetaki, T.	56-64	2156-2951	99.60% ZrO ₂ ; 0.20% SiO ₂ ; trace Al ₂ O ₃ ; Fe ₂ O ₃ , Ti ₂ O ₃	Not given	Calcined 2 hr. at 1600°C. ZrO ₂ No. 250 mesh powder dry pressed 1 ton/cm ² , fired 2 hr. at 1600°C Q - heating Q - cooling
Jones, M. C.	52-9	1290-3990	94.95% ZrO ₂ ; 14.5% CaO; 0.22-1.0% TiO ₂ ; 0.14-0.75% SiO ₂ ; 0.2-0.7% Fe ₂ O ₃	Not given	



ELECTRIC RESISTIVITY--ZIRCONIUM OXIDE + MAGNESIUM OXIDE

ELECTRIC RESISTIVITY -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
W. L. L. L. L. L. L. L. and L. L. L. L.	56-64	1935-3050	97.61% ZrO ₂ ; 2% MgO; 0.20% SiO ₂ p = 362 in/cm ²	Not given	From ZrO ₂ : 99.60% ZrO ₂ ; 0.20% SiO ₂ ; trace Al ₂ O ₃ , Fe ₂ O ₃ , TiO ₂ □ - heating □ - cooling
Ed4.	56-64	1800-3000	95.62% ZrO ₂ ; 4% MgO; 0.19% SiO ₂	Same as above	□ - heating □ - cooling
Ed4.	56-64	1636-3000	93.62% ZrO ₂ ; 6% MgO; 0.19% SiO ₂	Same as above	Same as above, but average of heating and cooling data
Ed4.	56-64	1636-3000	91.63% ZrO ₂ ; 8% MgO; 0.18% SiO ₂	Same as above	Same as above
Ed4.	56-64	1636-3000	89.64% ZrO ₂ ; 10% MgO; 0.18% SiO ₂	Same as above	Same as above

Symbol	Material Composition, %			Density	
	UO ₂	CaF ₂	ZrH ₂	lb m/ft ³	g/cm ³
O	99.9	0.1		537.6	8.611
	99.8	0.2		528.7	8.469
	99.5	0.5		519.1	8.315
	99.9	1.0		506.1	8.107
	98.0	2.0		465.0	7.449
□	99.9		0.1	481.4	7.712
	99.8		0.2	499.2	7.997
	99.5		0.5	472.5	7.569
	99.0		1.0	424.6	6.801

DENSITY -- URANIUM OXIDE + HALIDES

DENSITY -- URANIUM OXIDE + HALIDES

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-156	Belle, J. and Jones, L. J.	Room	UO ₂ + CaF ₂ system	Not given	Normal MCW UO ₂ powder mixed with metal oxide, pressed at 126,000 psi, fired 2 hr at 1400°C in steam
56-156	Ibid.	Room	UO ₂ + ZrH ₂ system	Same as above	Same as above

Symbol	Material Composition, %				Density	
	UO ₂	Al ₂ O ₃	MnO ₂	TiO ₂	ZrO ₂	lb _m /ft ³ g/cm ³
○	99.8	0.2				520.5 8.337
	99.5	0.5				515.7 8.260
	99.0	1.0				465.0 7.449
	98.0	2.0				444.5 7.120
□	99.9		0.1			497.9 7.975
	99.8		0.2			475.3 7.613
	99.5		0.5			496.5 7.953
	99.0		1.0			495.8 7.942
△	99.8			0.2		528.0 8.458
	99.7			0.3		525.3 8.414
◇	99.9				0.1	501.3 8.020
	99.8				0.2	533.5 8.546
	99.5				0.5	524.6 8.403

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DENSITY -- URANIUM OXIDE + OTHER OXIDES

DENSITY -- URANIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Zelle, J. and Jones, L. J.	56-154	Room	UO ₂ + Al ₂ O ₃ system	No. given	Normal MCW UO ₂ powder mixed with metal oxide, pressed at 126,000 psi, fired 1 hr at 1400°C in steam
Ibid.	56-154	Room	UO ₂ + MoO ₃ system	Same as above	Same as above
Ibid.	56-154	Room	UO ₂ + TiO ₂ system	Same as above	Same as above
Ibid.	56-154	Room	UO ₂ + ZrO ₂ system	Same as above	Same as above

<u>Symbol</u>	<u>Material Composition</u>	<u>Density</u>	
		<u>lb /ft³</u>	<u>g/cm³</u>
○	U ₂ O ₅	521	8.35
□	U ₃ O ₈	526	8.42
△	U ₃ O ₈	521	8.34
◇	UO ₃	121	1.94
▽	UO ₃	225	3.60
○	UO ₃	98.6	1.58

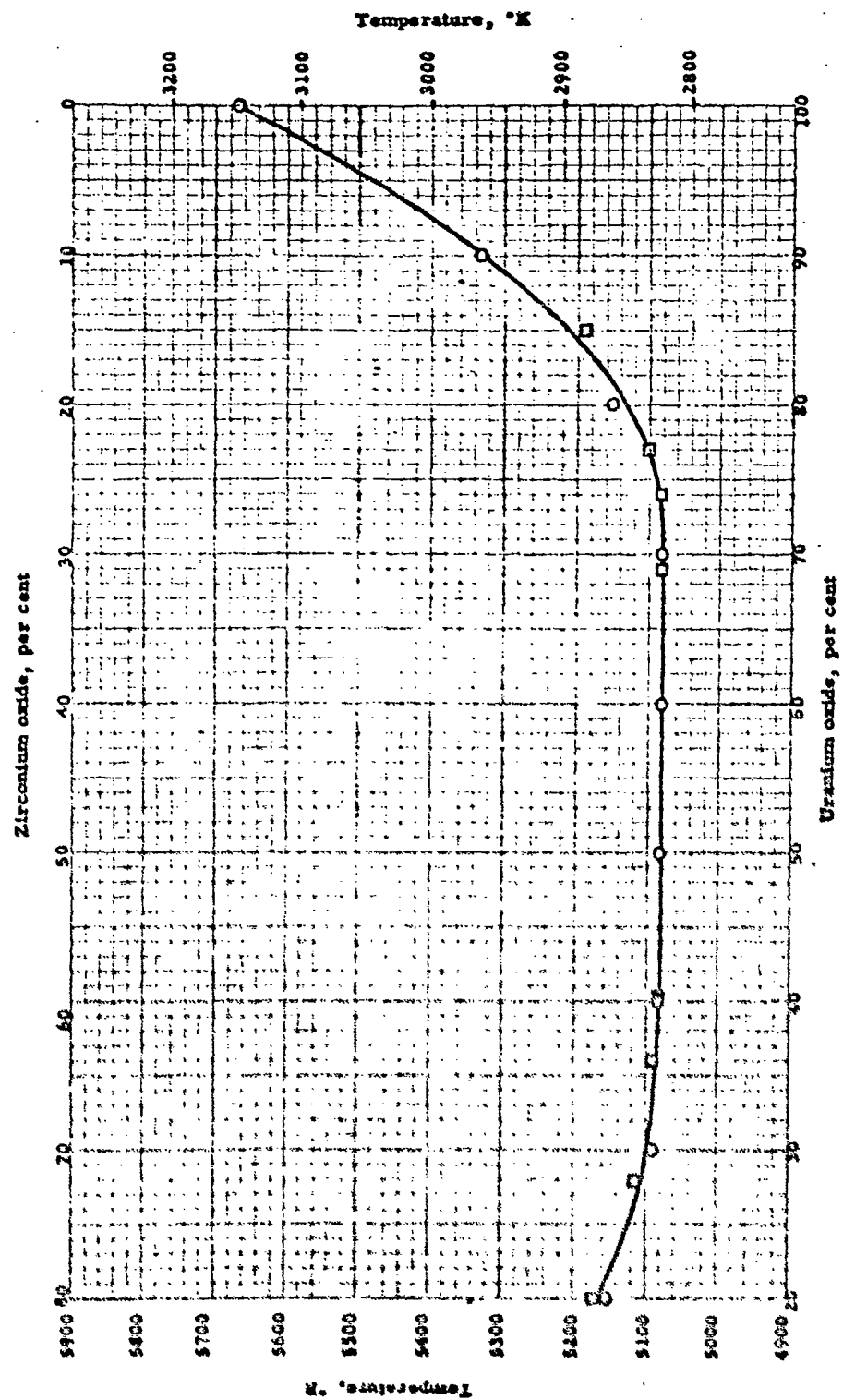
Note: For values for uranium dioxide see separate unit.

DENSITY -- URANIUM OXIDE

DENSITY -- URANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○ Zaeniger, M. G.	44-25	Room	U ₂ O ₅	p: computed from x-ray measurements of lattice	Auth. also quotes Bilts and Miller (1927) as 8.78 g/cm ³ and Pundie (1943) as 8.78 g/cm ³
□ Grunwald, F.	48-32	Room	U ₃ O ₈	p: computed from x-ray measurements of lattice	Type II
△ IDA	48-32	Room	Same as above	p: pycnometer	Type III
◇ Belle, J. and Jones, J. J.	54-156	Room	UO ₂	p: not given	Type III. Made by very slow denitration of uranyl nitrate hexahydrate (UNH)
▽ IDA	54-156	Room	Same as above	p: same as above	
○ IDA	54-156	Room	Same as above	p: same as above	
			For UO ₂ see separate unit.		



MELTING POINT -- URANIUM OXIDE + ZIRCONIUM OXIDE

MELTING POINT -- URANIUM OXIDE + ZIRCONIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Laubertson, W. A. and Mueller, M. H.	53-132	5032-5667	UO ₂ - ZrO ₂ series (0-80% ZrO ₂)	MP; not given	Made from approx. 98% pure ZrO with 2% H ₂ O, 0.035% other impurities and probably pure UO ₂
□	Idid.	53-135	5032-5190	Same as above	Same as above	Same as above

PROPERTIES OF URANIUM DIOXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	684.8 lb _m /ft ³	10.97 g/cm ³
Melting Point	5670°R	3150°K
Heat of Fusion		
Heat of Vaporisation. . .		
Heat of Sublimation . . .		

REPORTED VALUES .

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	639.9	10.25
□	661.7	10.60
△	647.4	10.37
◇	683.6	10.95
▽	680.5	10.90
○	625.5 ± 6	10.02 ± 0.1
○	693.6 ± 13	11.11 ± 0.2
○	684.8	10.97

<u>Melting Point:</u>	°R	°K
○	5676 ± 36	3153 ± 20
○	5665 ± 27	3148 ± 15
○	5460 ± 54	3033 ± 30

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporisation:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF URANIUM DIOXIDE

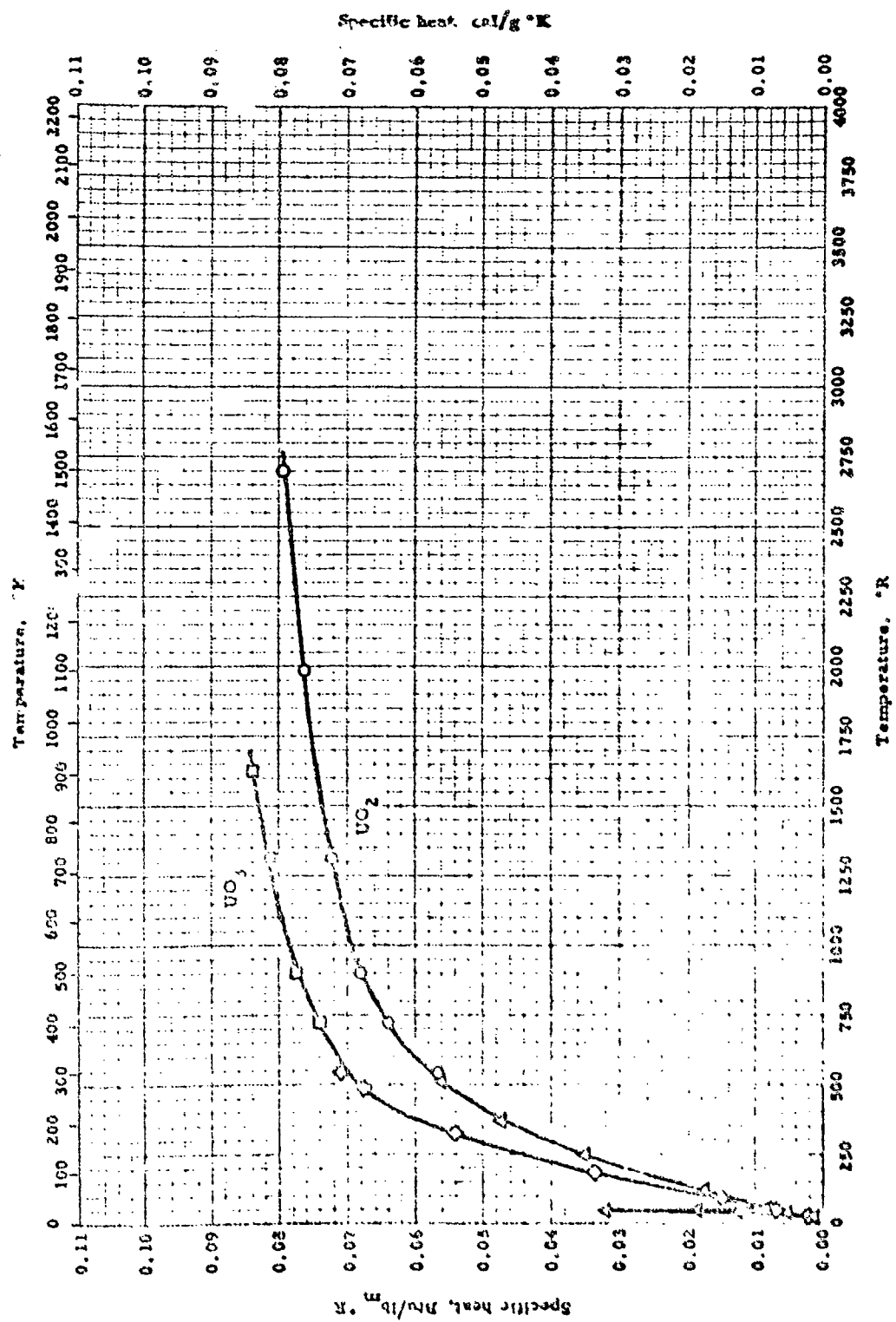
REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lambertson, W. A. and Handwerk, J. H.	56-5 also 54-151 52-131	Room 5676	Typical analysis before fabrication: 0.083% MgO; 0.002% Al ₂ O ₃ ; 0.001% ea. copper oxide, Fe ₂ O ₃ , SiO ₂ . Supplied by Mallinckrodt as -325 mesh	p: not given MP: inspected as powdered sample with grain size below 74μ after heating it in W crucible in He atmos. at const. temp. Temp. meas. by optical pyrometers:	Pressed at 70,000 psi; fired at 1750°C in H ₂ atmos.
□	Ibid.	56-5 54-151	Room	Same as above	Pycnometer with water	Pebble-milled 56 hr. then same as above
△	Ibid.	56-5 54-151	Room	Same as above	p: not given	Calcined at 1750°C; pebble-milled 16 hr. then same as □
◇	Ibid.	56-5 54-151	Room	Same as above	p: not given	Pebble-milled 140 hr. then same as □
▽	Ibid.	56-5	Room	Same as above	p: not given	Pressed at 800 psi, fired at 1750°C in H ₂ atmos.
○	Ibid.	56-5	Room	"Pure" manufactured by Norton Co.	p: x-ray meas. of lattice parameter	Electrically fused
□	Lambertson, W. A. and Mueller, M. H.	53-133	Room	UO ₂	p: not given	
△	Rudorff, W. and Valet, G.	53-85	Room	UO ₂	p: not given	
◇	Bruch, C. A. and Cashin, W. M.	56-109	5442	UO ₂	MP: visual observation of sample resting in apex of "V"-shaped ribbon heater element. Temp. by optical pyrometer sight- ing on apex	
▽	Wisnyski, L. G. and Pijunowski, S. W.	57-399	5460	UO ₂ (atomic ratio U:O = 1.98) Mfr. by Mallinckrodt	MP: visual observation of sample resting in apex of "V"-shaped ribbon heater element. Temp. by optical pyrometer sight- ing on apex. Also obser- vation of break in time- temp. curve.	

PROPERTIES OF URANIUM DIOXIDE (cont.)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
2	Burdick, M. D. and Parker, M. C.	55-106	Room	UO ₂ : 0.01-0.001% ea. Al, Fe; 0.001-0.0001% ea. P; Ca, Mg < 0.001% Ca; 0% spectroscopically of all others. Supplied as arc-fused material by Marian Co.	bulk density by Hg dis- placement	



SPECIFIC HEAT -- URANIUM OXIDE

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WADC TR 58-475

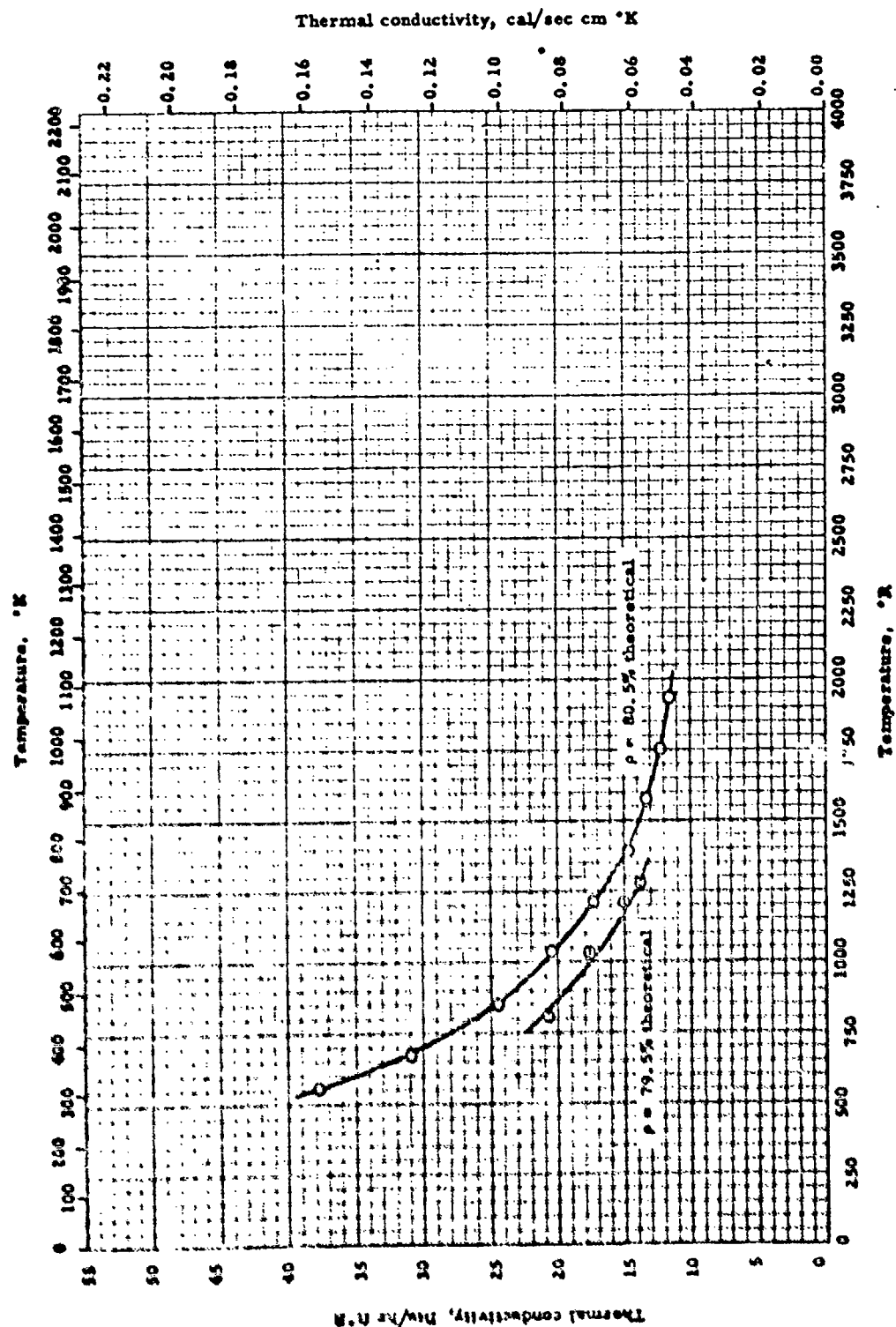
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SPECIFIC HEAT -- URANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	McGee, G. E. and Kallay, E. E.	67-18 also 42-11	540-2760	UO ₂ : 88.26% U (theor. 88.15%)	Drop method; copper block calorimeter	Mean enthalpy deviation 0.1%
Q	Did.	67-18 also 42-11	540-1620	UO ₂ : 83.02% U (theor. 83.22%)	Same as above	Same as above
Δ	Jones, W. M., Gordon, J. and Long, E. A.	52-111	27-540	99.3% UO ₂ ; 0.7% UO ₃ ; traces of other metal oxides. 88.26% U	Not described here, re- fers to others. Temp. by calibrated gold resis- tance thermometer	Powder of well crystallized particles. Auth. est. accu- racy ± 0.2% above 35°K
◇	Did.	52-111	27-540	UO ₂ : 0.009% H ₂ O	Same as above	Made by decomposing uranyl nitrate 8 hr at 300°C, ground dried 3 hr at 100°C. Auth. est. accuracy ± 0.2% above 35°K



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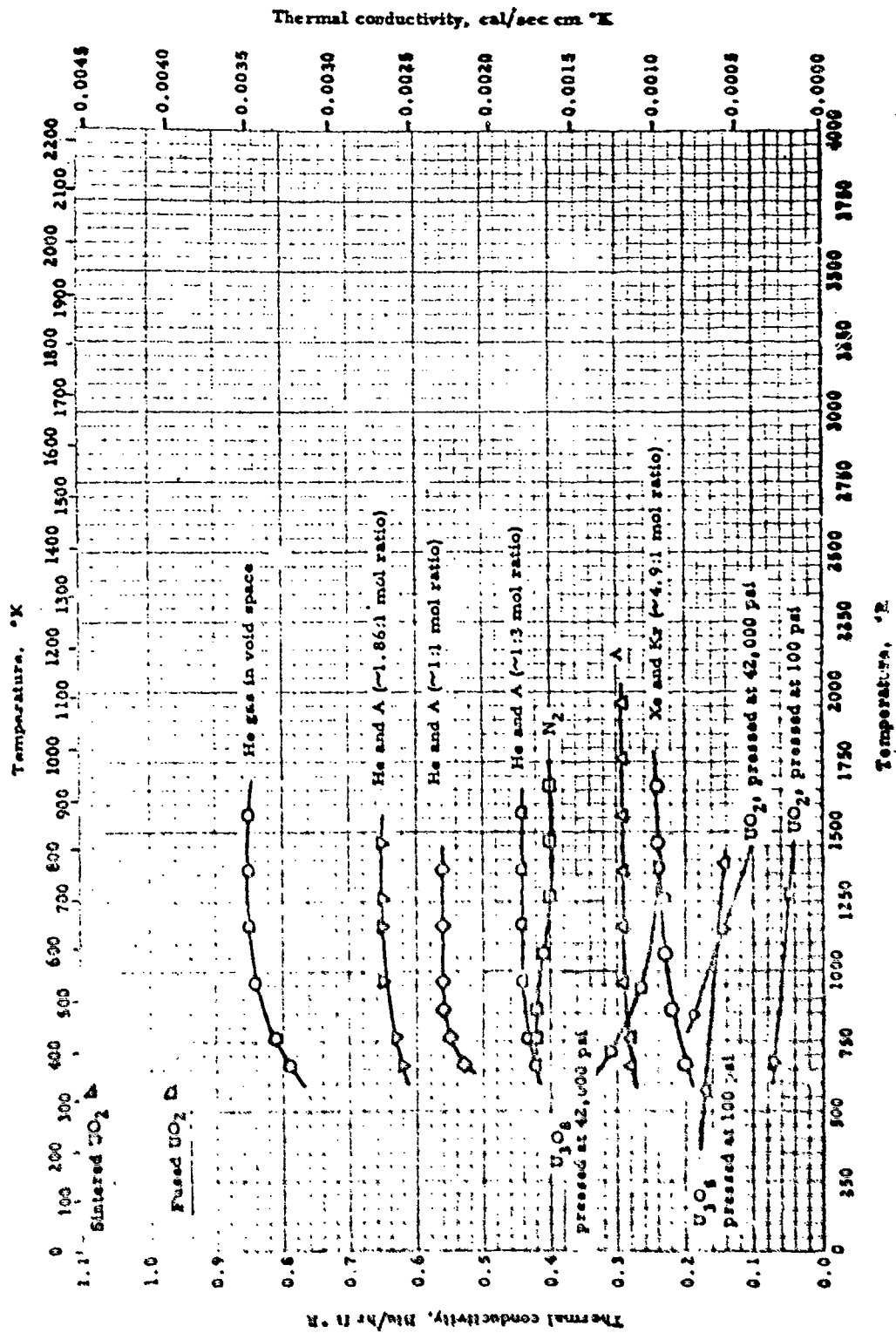
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Thermal conductivity -- URANIUM OXIDE + BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- URANIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
57-148	McCreight, L. R.	555-1935	70.9% UO_2 ; 29.1% BeO $p = 80.5\%$ of theor.	Two methods: a. comparative, rods b. axial heat flow in rod	Sintered
57-148	Ibid.	810-1275	Same as above $p = 79.5\%$ of theor.	Same as above	Same as above

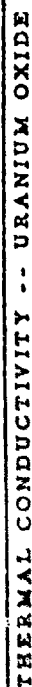


Thermal conductivity -- URANIUM OXIDE POWDER

THERMAL CONDUCTIVITY -- URANIUM OXIDE POWDER

REFERENCE INFORMATION

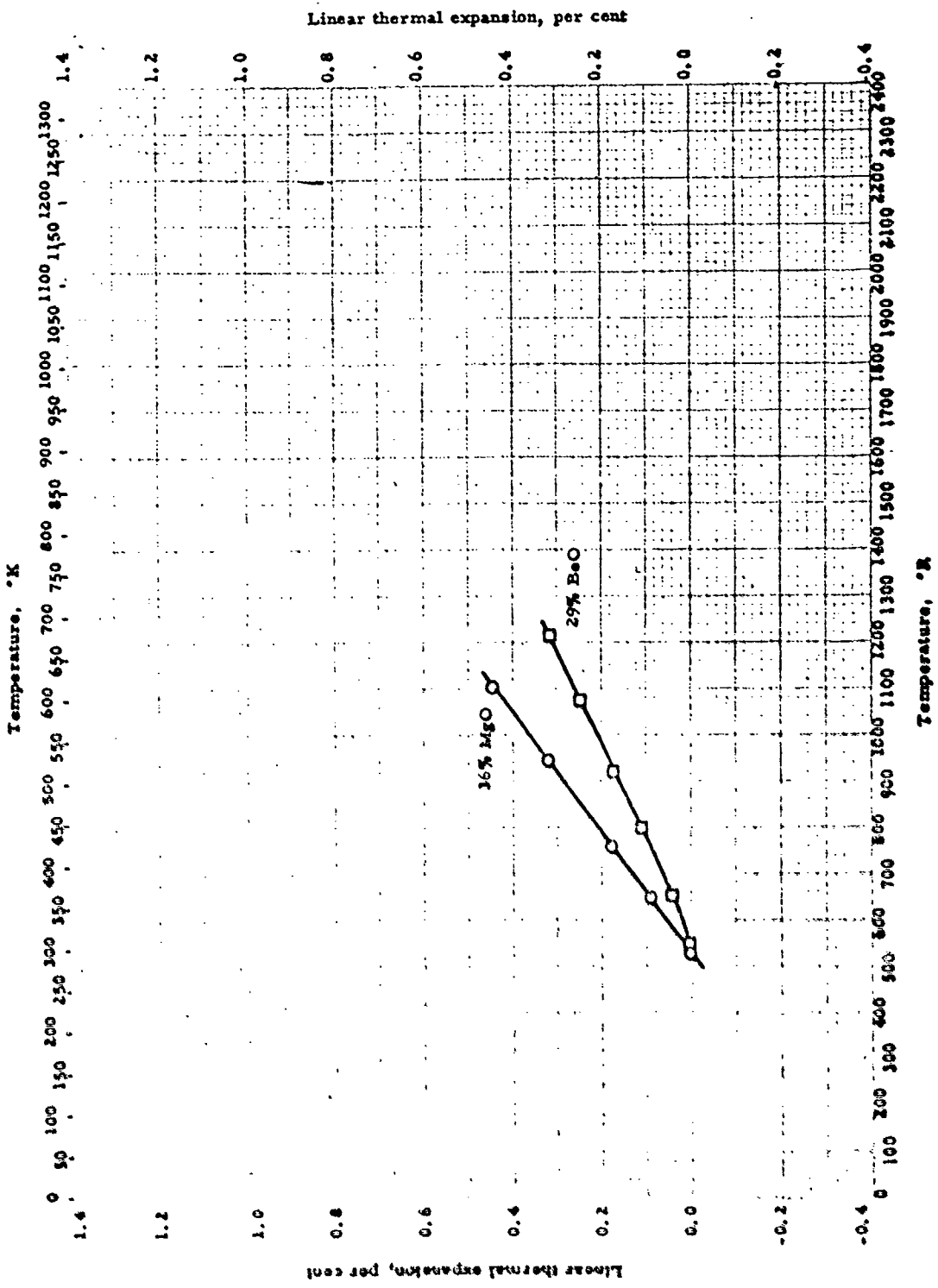
	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Doegli, J. S. and Detester, R. G.	35-34	560-1560	Uranium Oxide Powder. Void fraction = 0.405; $\rho = 398 \text{ lb./ft}^3$; 0% re- tained on 0.0059 in. mesh; 59% on 0.0041 in. mesh; 41% on 0.00248 in. mesh	Radial heat flow in cylinder	Gas contained in void space was He at 89.3-136.9 psia
□	Ibid.	35-34	760-1660	Same as above	Same as above	Gas contained in void space was N ₂ at 49.3-83.3 psia
△	Ibid.	35-34	660-1960	Same as above	Same as above	Gas contained in void space was A at 44.3-94.4 psia
○	Ibid.	35-34	660-1260	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 0.953 to 1; pressure level 39.4- 96.3 psia
▽	Ibid.	35-34	660-1660	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 1.827 to 1; pressure level 47.3- 84.3 psia
○	Ibid.	35-34	660-1660	Same as above	Same as above	Gas contained in void space was a mixture of Xe and Kr; vol. ratio 4.898 to 1; pressure level 18.8- 74.3 psia
○	Ibid.	35-34	660-1960	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 0.333 to 1; pressure level 46.3- 84.3 psia
○	Snyder, T. M. and Kamm, R. L.	35-95	582-1392	U ₃ O ₈ powder	Single flat plate with guard heaters	Pressed at 100 psi
○	Ibid.	35-95	710-1360	U ₃ O ₈ powder	Same as above	Pressed at 42,000 psi
○	Ibid.	35-95	670-1290	UO ₂ powder	Same as above	Pressed at 100 psi
○	Ibid.	35-95	840-1150	UO ₂ powder	Same as above	Pressed at 42,000 psi
○	Ibid.	35-95	582	UO ₂ fused powder	Same as above	
△	Ibid.	35-95	582	UO ₂ sintered powder	Same as above	



THERMAL CONDUCTIVITY -- URANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-1 430 53-63 53-85	Kingery, W. D. and Franci, J.	852-2292	UO ₂ ; Bulk $\rho = 499 \text{ lb}_m/\text{ft}^3$; porosity = 26.7%	Comparative; rods	Cast from suspension; fired at 1980°C in vacuum
54-5 also 53-65	Lambertson, W. A. and Handwerk, J. H.	672-2292	UO ₂ ; $\rho = 504 \text{ lb}_m/\text{ft}^3$	Not given	
53-17	Weeks, James L. and Seifert, R. A.	618	UO ₂ ; $\rho = 637 \text{ lb}_m/\text{ft}^3$	Comparative; rods	
54-68	Reuch, W. G.	618	UO ₂ ; $\rho = 639 \text{ lb}_m/\text{ft}^3$	Comparative; rods	
53-69	Norton, F. H. and Kingery, W. D.	672-1032	UO ₂ ; Bulk $\rho = 375 \text{ lb}_m/\text{ft}^3$; porosity = 45%	Ellipsoidal envelope	
56-110	Nedetz, J. C. and Fieldhouse, L. B.	856-3494	UO ₂ ; $\rho = 510 \text{ lb}_m/\text{ft}^3$ (74.95% of theo.)	Power; stacked disks	Ground; cold pressed at 40,000 psi; dried; fired to 1400°C in dry H ₂ ; to 1500°C in steam; held two hr; furnace cooled in H ₂
51-85	Englander, M.	528-942	UO ₂	Twin plate without guards	Sintered. Auth. est. accuracy ± 10%
55-95	Snyder, T. M. and Kamm, R.	582	UO ₂ ; fused	Single flat plate with guard heater	
55-95	Id.	582	UO ₂ ; sintered	Same as above	



LINEAR THERMAL EXPANSION -- URANIUM OXIDE + OTHER OXIDES

LINEAR THERMAL EXPANSION -- URANIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

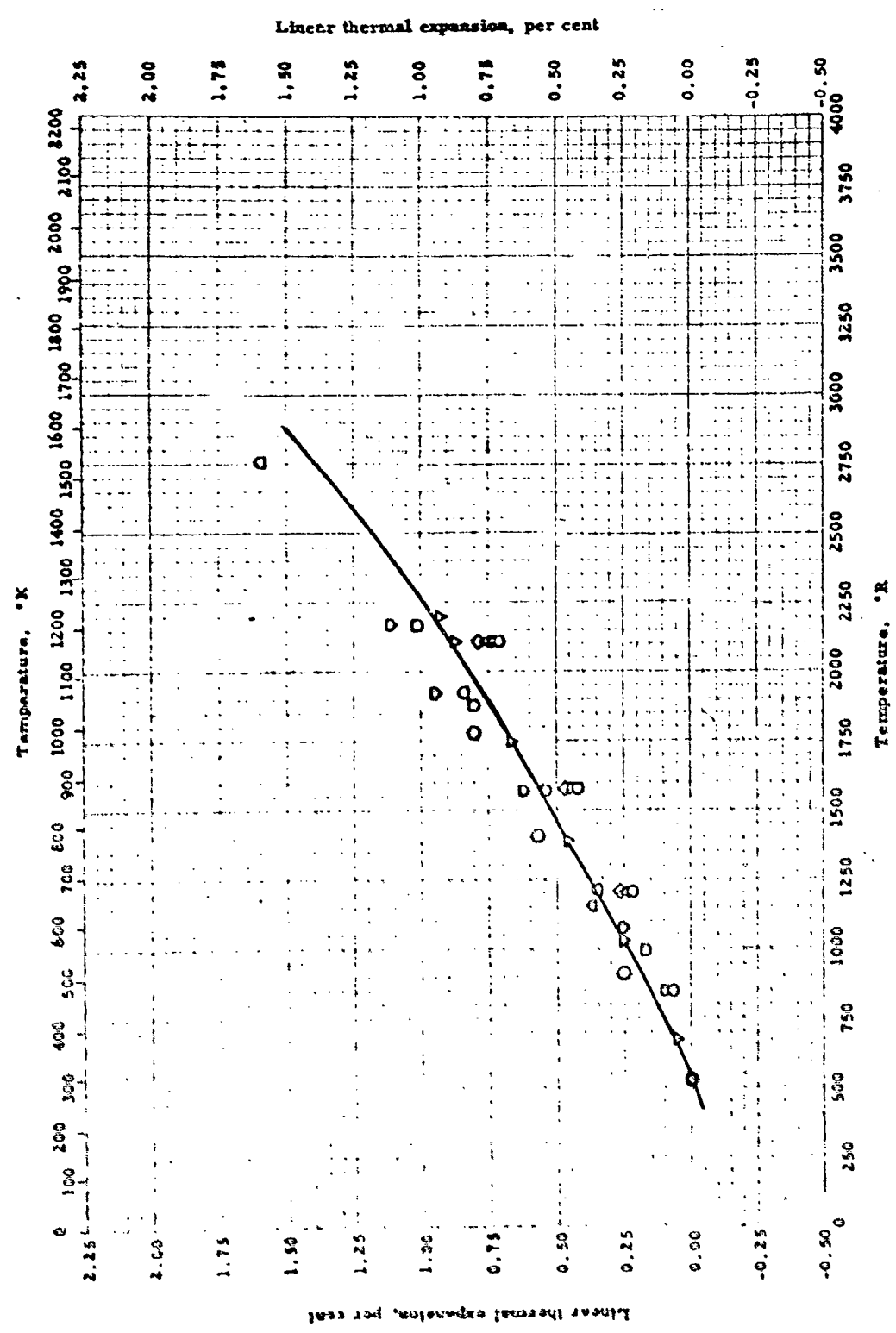
Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Mc Creight, L. R.	52-119	528-1104	63.8% UO_2 ; 36.2% MgO	Gaertner interferometer in a argon atmos.	Pressed from powder, sintered, 80% of theoretical density
□	Idid.	52-119	528-1212	70.9% UO_2 ; 29.1% BeO	Same as above	Pressed from powder, sintered at 1850°C, 80% of theoretical density

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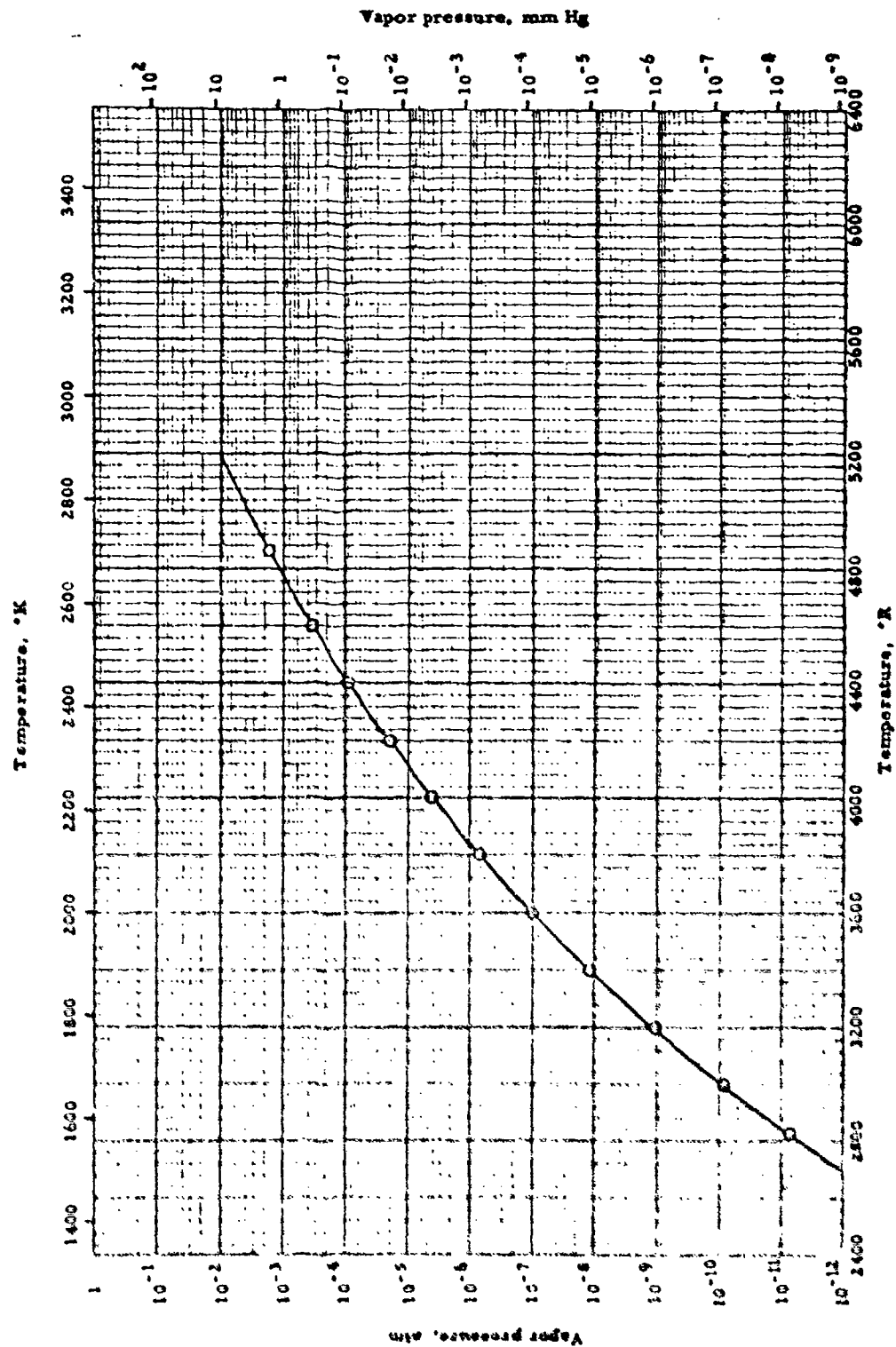


LINEAR THERMAL EXPANSION -- URANIUM OXIDE

LINEAR THERMAL EXPANSION -- URANIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Temp., °C	Material Composition	Test Method	Remarks
ND-1	Murray, P. and Thachray, R. W.	528-2112	UO ₂ ; $\rho = 450 \text{ lb}_m/\text{ft}^3$	Dilatometer	Sintered; tested at 10°C/min. rise in argon atmos.
ND-1	Ibid.	528-2112	Same as above	Same as above	Sintered; tested at 3.5°C/min. rise in argon atmos.
ND-1	Ibid.	528-2112	UO ₂ ; $\rho = 533 \text{ lb}_m/\text{ft}^3$	Same as above	Sintered; tested at 10°C/min. rise in argon atmos.
ND-1	Ibid.	528-2112	UO ₂ ; $\rho = 631 \text{ lb}_m/\text{ft}^3$	Same as above	Sintered; tested at 3.5°C/min. rise in argon atmos.
56-5	Lambertson, W. A. and Handwerkh, J. H.	528-2202	99.8% UO ₂ ; 0.08% MgO; 0.002% Al ₂ O ₃ ; 0.001% ea. CuO, Fe ₂ O ₃ , SiO ₂ $\rho = 574 \text{ lb}_m/\text{ft}^3$	Interferometer	Slip cast; fired to 1750°C in H ₂ atmos.; tested at 205°C/hr. rise
52-19	Thewlis, J.	528-1788	UO ₂	X-ray diffraction	Arc fused, milled 20 hr., 1% carbowax added, pressed at 10,000 psi in mold, at 45,000 psi hydrostatically, matured in A. atm. for 30 min. at 2000°C. Plotted avg. of 2 heating and cooling runs within 3%
55-144	Burdick, M. D. and Parker, H. S.	528-2760	UO ₂ ; 0.001 - 0.01% ea. Al, Fe; 0.0001 - 0.001% ea. Ca, Mg; 0.0001% Ca	Not given	Pressed from powder; sintered at 1950°C in H ₂ atm.
52-119	McCraith, L. R.	528-1158	UO ₂ ; $\rho = 85\%$ theoretical	Gastner interferometer	Prepared from Springfield UO ₂ powder, pressed at 20,000 psi, sintered 3 hr. at 1400°C in argon. Sample 1
54-103	Bell, L. P. and Maslin, S. M.	492-2170	UO ₂ ; $\rho = 624 \text{ lb}_m/\text{ft}^3$	Dilatometer	Same as above, Sample 2
54-103	Ibid.	492-2112	Same as above	Same as above	

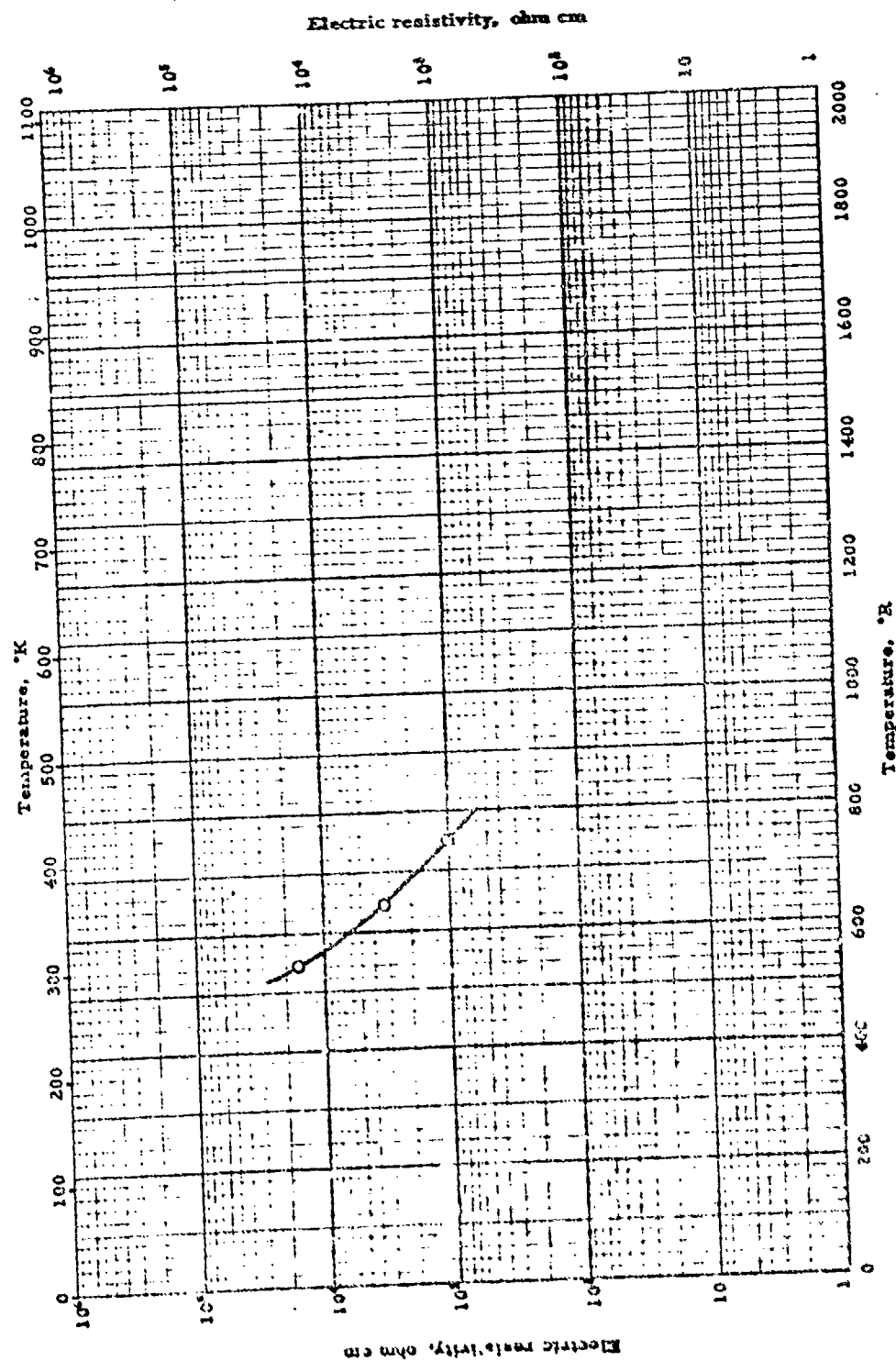


VAPOR PRESSURE -- URANIUM OXIDE

VAPOR PRESSURE -- URANIUM OXIDE

REFERENCE INFORMATION

Temp Used	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Ackerman, R. J., Collins, P. W., and Waters, M. J.	56-43	2831-4850	UO ₂	Knudsen effusion cell; (alpha particle counting)	W cell

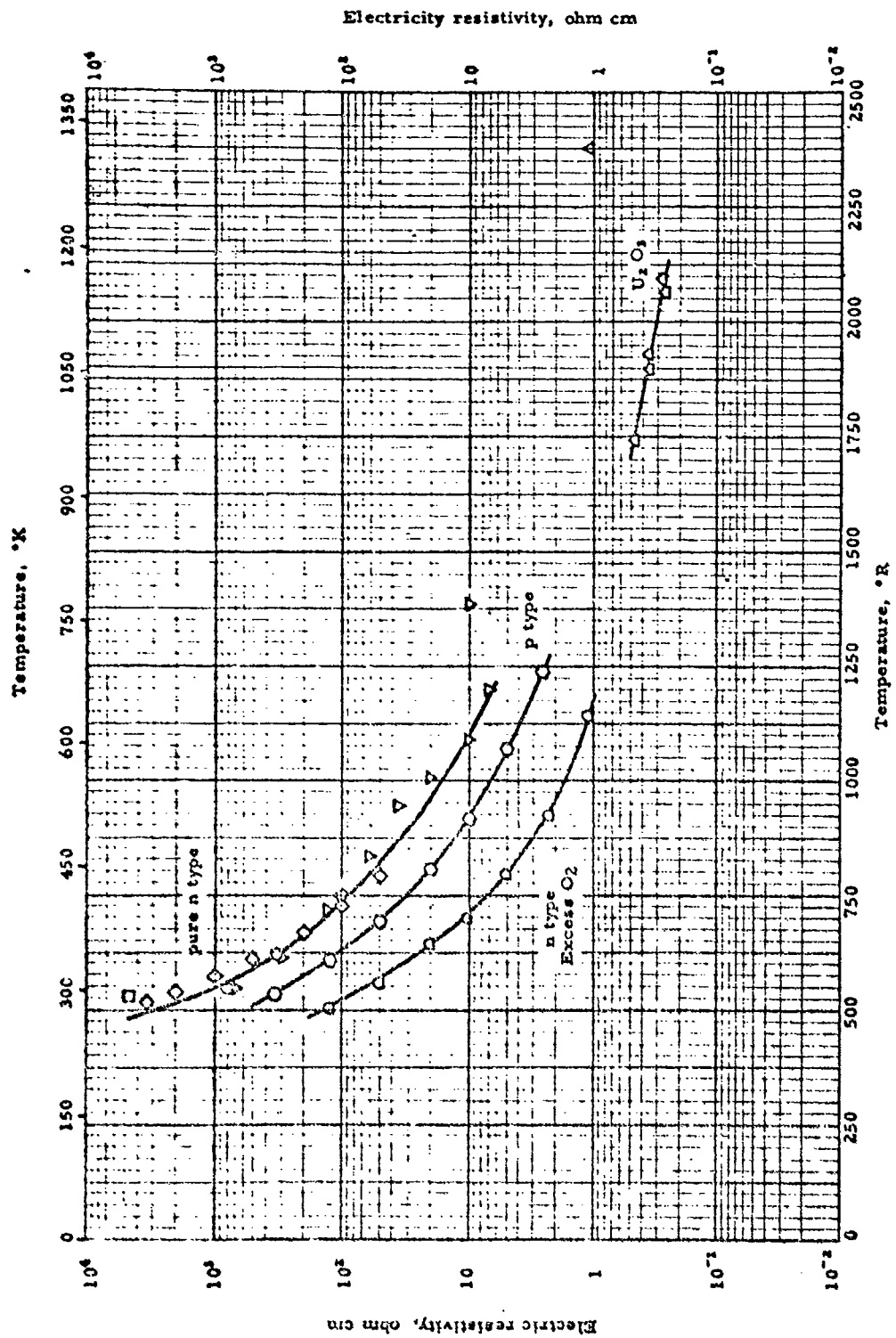


ELECTRIC RESISTIVITY -- URANIUM OXIDE + THORIUM OXIDE

ELECTRIC RESISTIVITY -- URANIUM OXIDE + THORIUM OXIDE

REFERENCE INFORMATION

Dr. J. J. G. Green, D. M.	Ref.	Range, °F	Material Composition	Test Method	Remarks
C	54-163	545-750	50% UO ₂ : 50% ThO ₂	Potential drop. Sample temp. by Chromel-Alumel thermocouple	Mixed from elements with <0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H ₂



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ELECTRIC RESISTIVITY -- URANIUM OXIDE

ELECTRIC RESISTIVITY -- URANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○ Gruen, D. M.	54-143	545-750	UO ₂	Potential drop; Chromel-Alumel thermocouple	Mixed from elements with < 0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H ₂
□ Zundorf, W. and Valet, G.	53-85	Room	UO ₂	Not given	Powders pressed at 500 g/cm ² pressure, roasted in a high vacuum until resistivity became constant. Auth. est. accuracy ± 2%
△ Hauffe, K.	41-26	2375	UO ₂	Potential drop	Sintered at 1600-1800°C
◇ Willardson, R. K., Moody, J. W. and Goering, H. L.	56-161	515-789	UO ₂ - <0.0003% metallic impurities; n-type	Potential drop, sample temp. by Chromel-Alumel thermocouple	Pressed from Mallinckrodt UO ₂ powder at 100,000 psi (no binder), sintered 1 hr. at 2050°C; corrected to zero porosity. $\rho = 86\%$ theoretical
▽ Ibid.	56-161	542-1720	Same as above	Same as above	Same as above, except sintered 1 hr. at 1600°C, and $\rho = 79-95\%$ theoretical (two samples)
○ Ibid.	56-161	534-1240	Three samples ranging UO ₂ 0.02 - 2.160 p-type	Same as above	Mallinckrodt UO ₂ powder oxidized, pressed at 100,000 psi (without binder), not sintered, annealed at 400°C, quenched. $\rho = 60\%$ theoretical
□ Ibid.	56-161	503-1215	Three samples ranging UO ₂ 2.206 - 2.353 n-type	Same as above	Same as above
○ Hauffe, K.	41-26	1742-2093	U ₂ O ₃	Potential drop	At 1 atm. O ₂

PROPERTIES OF PLUTONIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	590 ₃₄₀₀ °R Btu/lb _m	330 ₁₉₀₀ °K cal/g

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

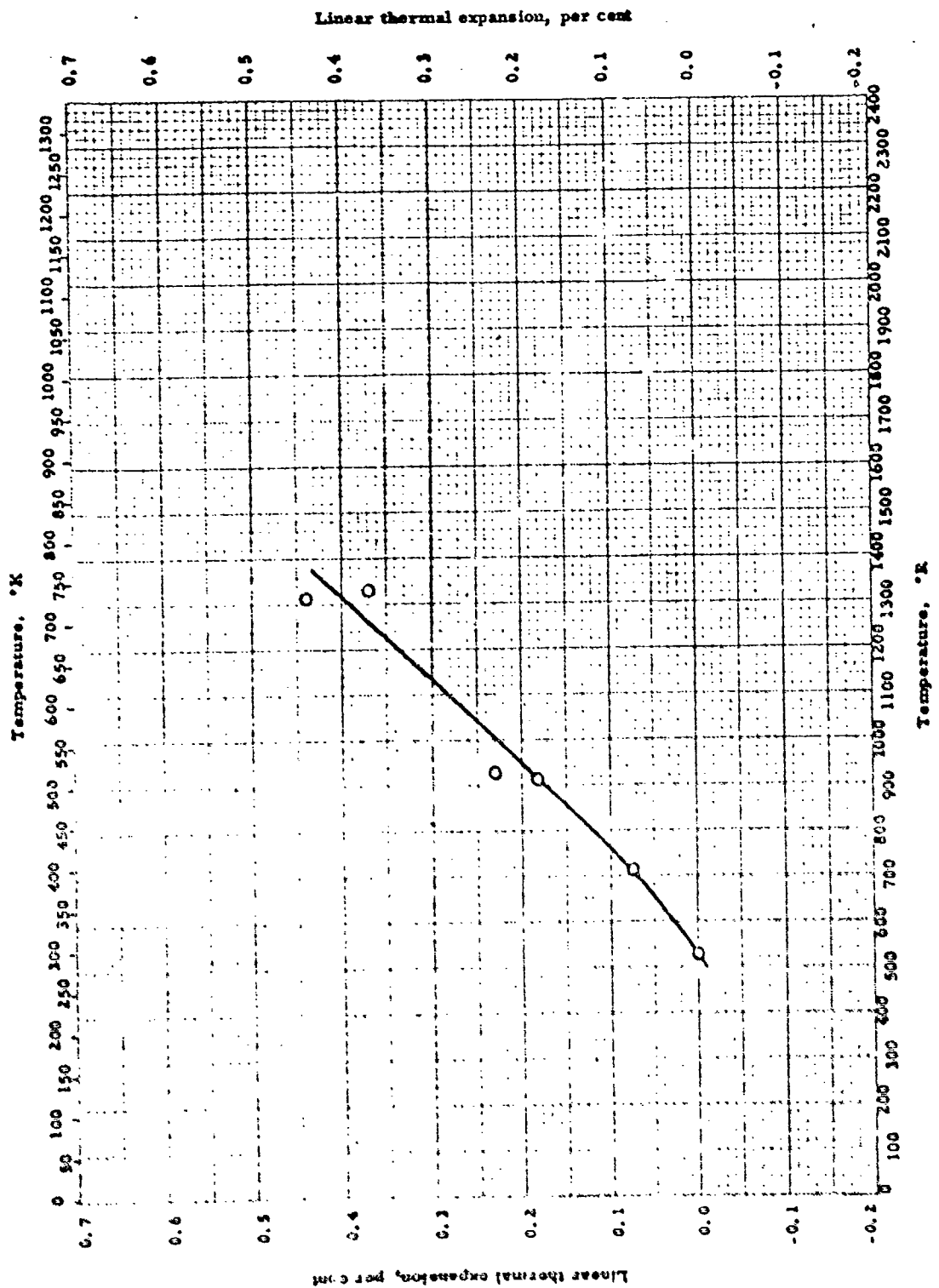
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g
 O 590₃₄₀₀°R 330₁₉₀₀°K

PROPERTIES OF PLUTONIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Compton, A. H. and Allison, S. A.	43-20	3011-3731	P ₂ O ₅	Δh_v : from vapor pressure measurements	Authors estimate that "this value is probably too high, but of reasonable order of magnitude".

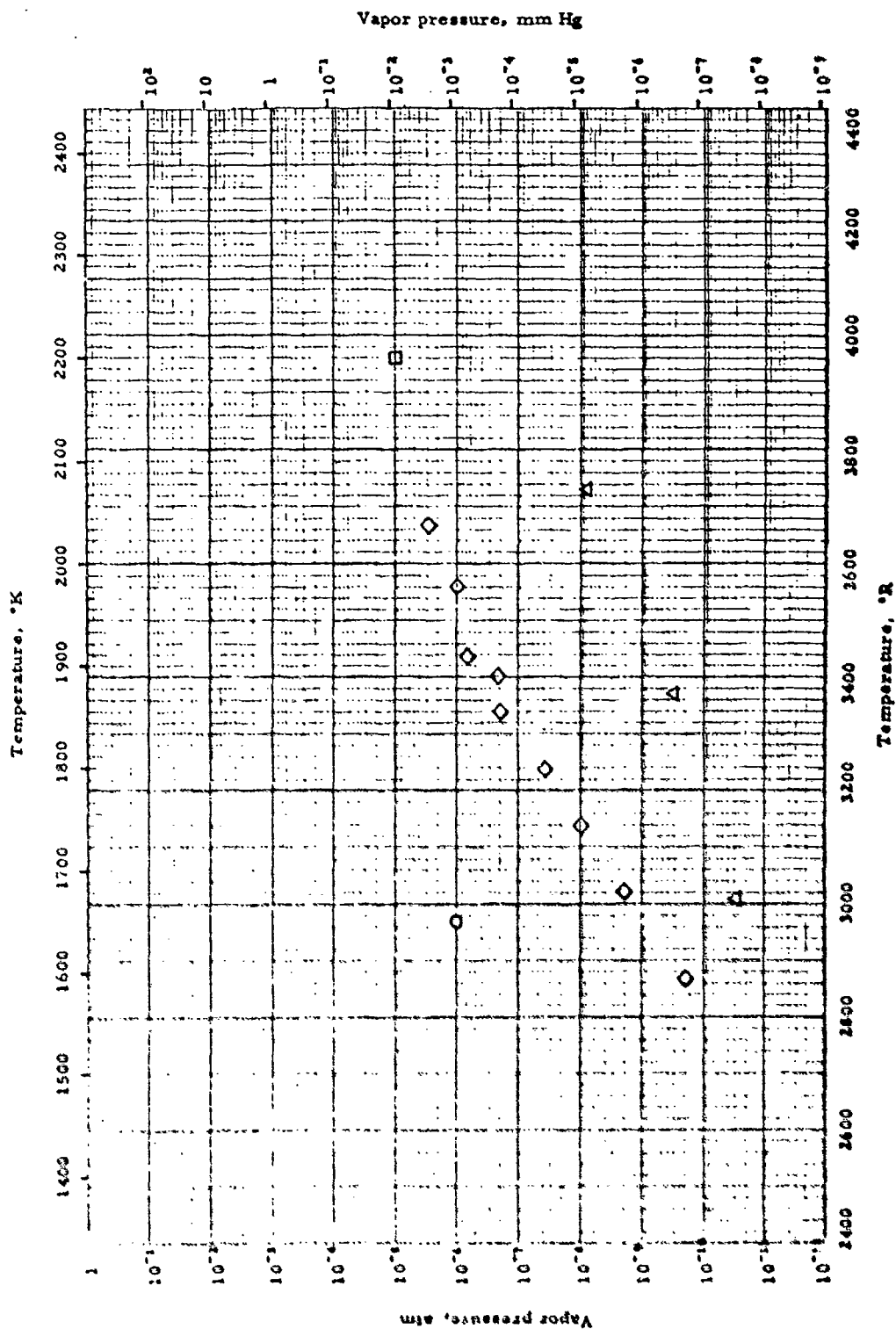


LINEAR THERMAL EXPANSION -- PLUTONIUM OXIDE

LINEAR THERMAL EXPANSION -- PLUTONIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
57-192	Mardon, P. G. and Waliron, M. B.	528-1330	PuO ₂	X-ray meas. of lattice	Authors consider values of limited accuracy



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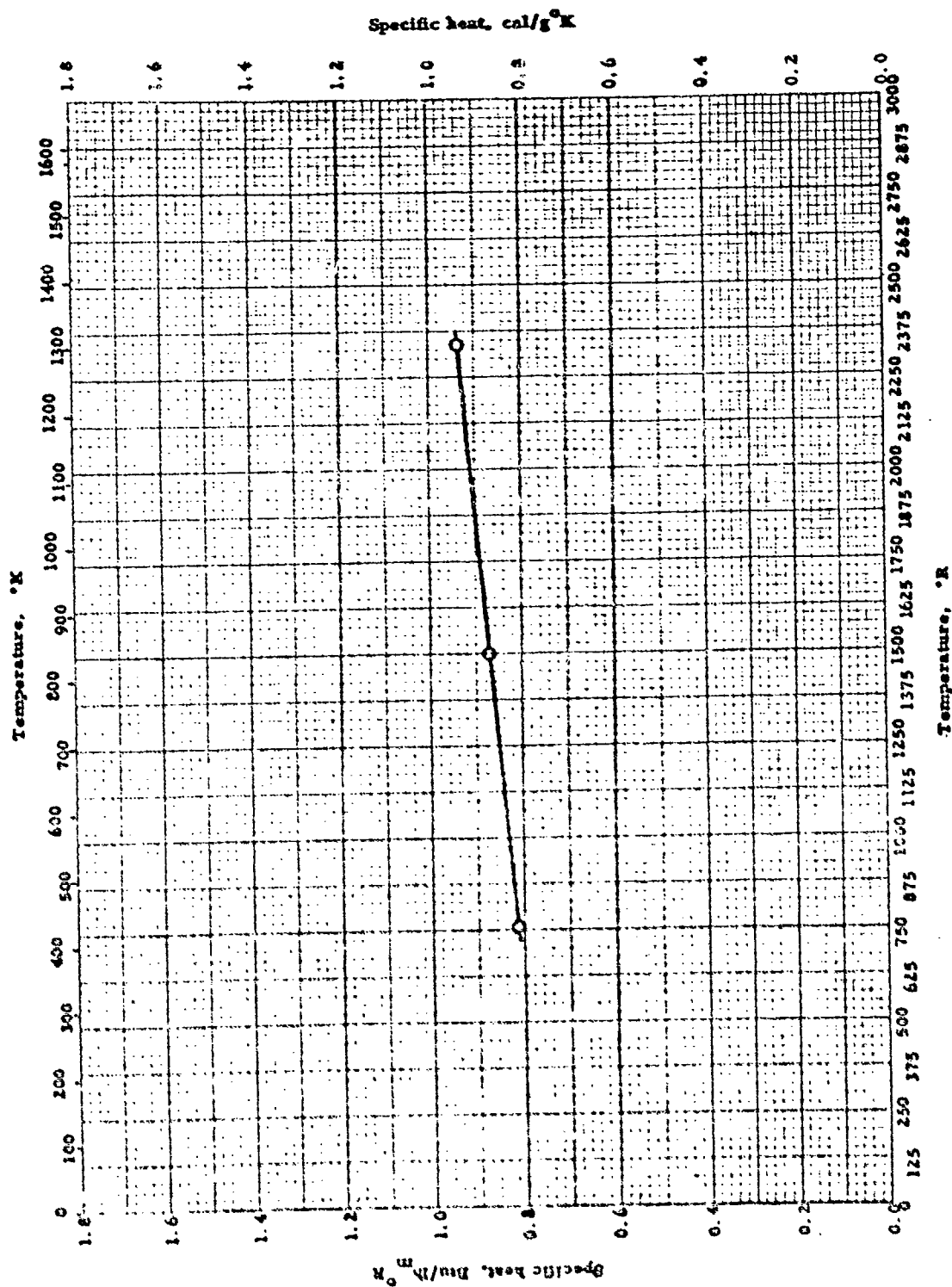
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VAPOR PRESSURE -- PLUTONIUM OXIDE

VAPOR PRESSURE -- PLUTONIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○ Brewster, L., Dremley, L., et al.	49-65	2970	PuO	Not described here, refers to others	Estimate from corresponding uranium compound
○ Ibid.	49-65	1960	PuO ₂	Same as above	Auth. est. only order of magnitude
△ Compton, A. H. and Allison, S. A.	43-20	2011-3731	Pu Oxide	Knudsen type test, but not an effusion vessel, only an orifice. Temp. by optical pyrometer	
○ Phipps, T. E. et al.	50-63	2861-3703	PuO ₂ + unknown reduced Pu Oxide	Knudsen cell with radioactive counting. Temp. by optical pyrometer	

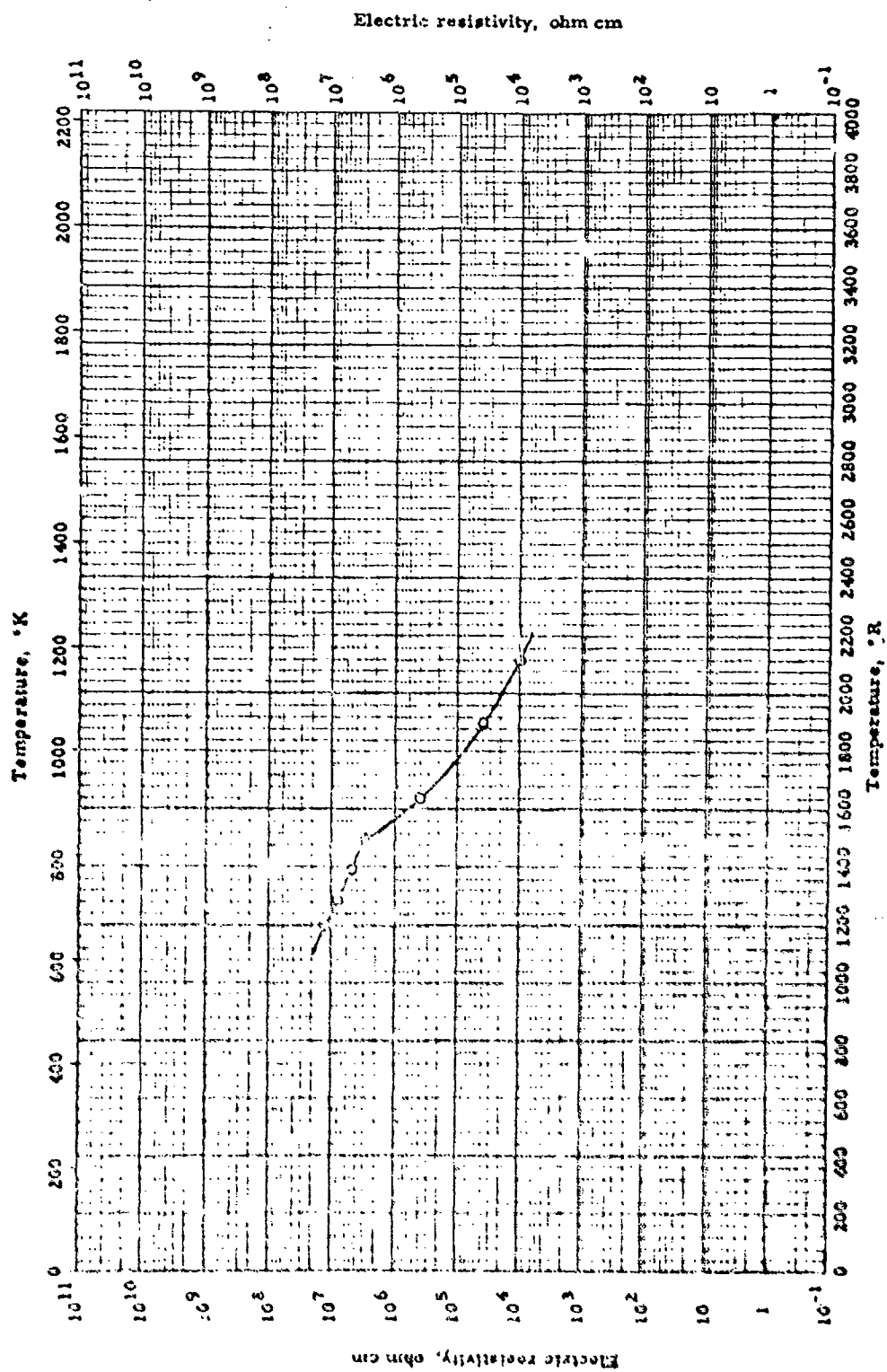


SPECIFIC HEAT -- BARIUM OXIDE

SPECIFIC HEAT -- BARIUM OXIDE

REFERENCE INFORMATION

O	Investigator	Ed.	Range, °R	Material Composition	Test Method	Remarks
O	Lander, J.J.	51-78	750-2340	99% BaO, ~1% SiO ₂	Drop method, calibrated with P ₃ sample.	Material prepared by decomposing BaO ₂ . Computed C _p from quadratic equation fitted to author's enthalpy values by least square routine at ARF.



ELECTRIC RESISTIVITY -- BARIUM OXIDE

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ELECTRIC RESISTIVITY -- BARIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
C. Chakravorty, A.P.	56-73	200-2150	BaO	Potential drop; sample temp. by thermocouple and optical pyrometer	Prepared from chemically pure polycrystalline materials. Sintered at 0.46 MP for 2 hr. in vacuum

PROPERTIES OF CADMIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	434 lb _m /ft ³ *	6.95 g/cm ³ *
Melting Point.	2930°R *	1630°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	861,1850°R Btu/lb _m	478,1028°K cal/g

* Handbook Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

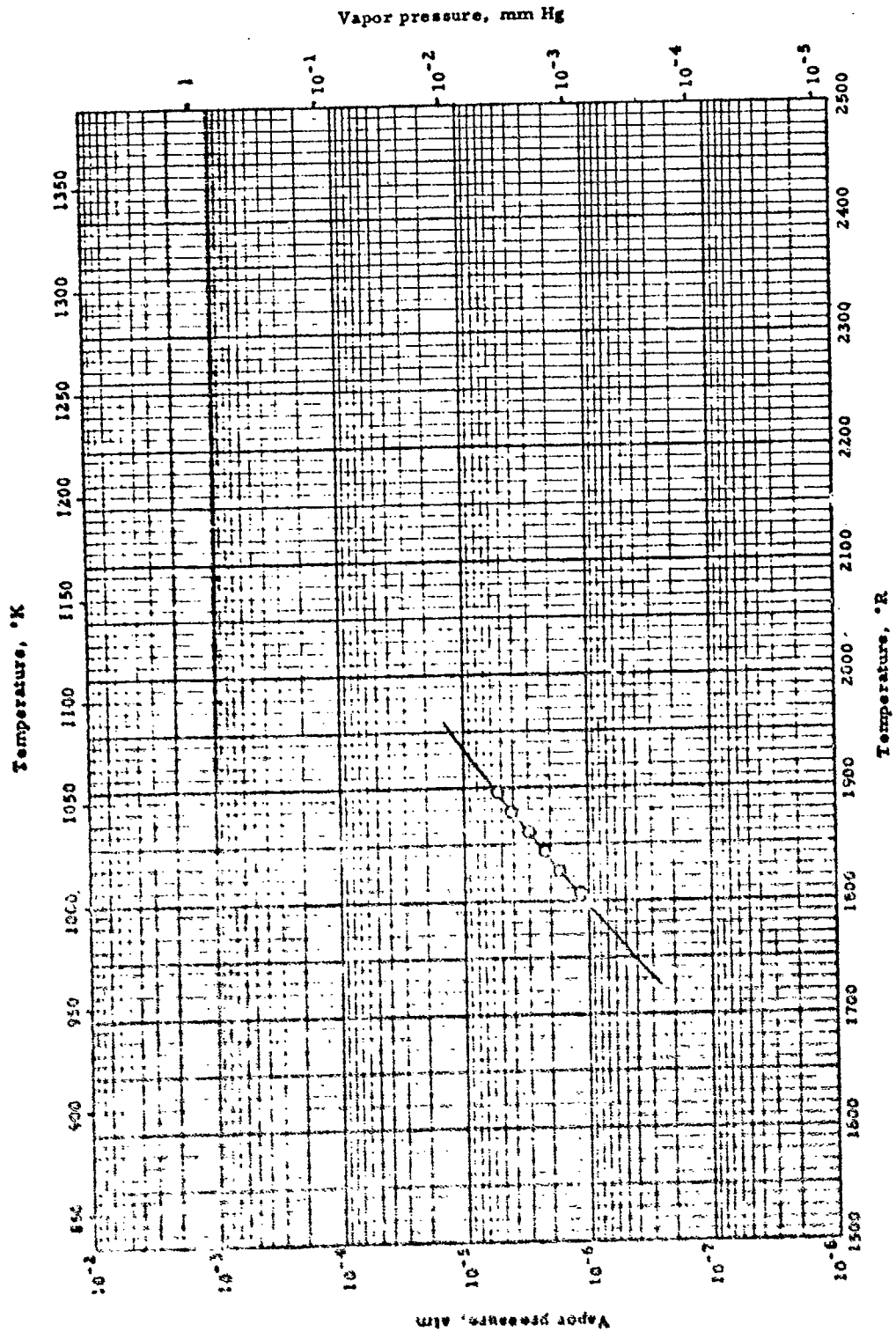
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g
 O 861,1850°R 478,1028°K

PROPERTIES OF CADMIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
Q	Lyons, K.	Q-3	1851	CdO	Ab, from vapor pressure measured by Knudsen effusion cell	



VAPOR PRESSURE -- CADMIUM OXIDE

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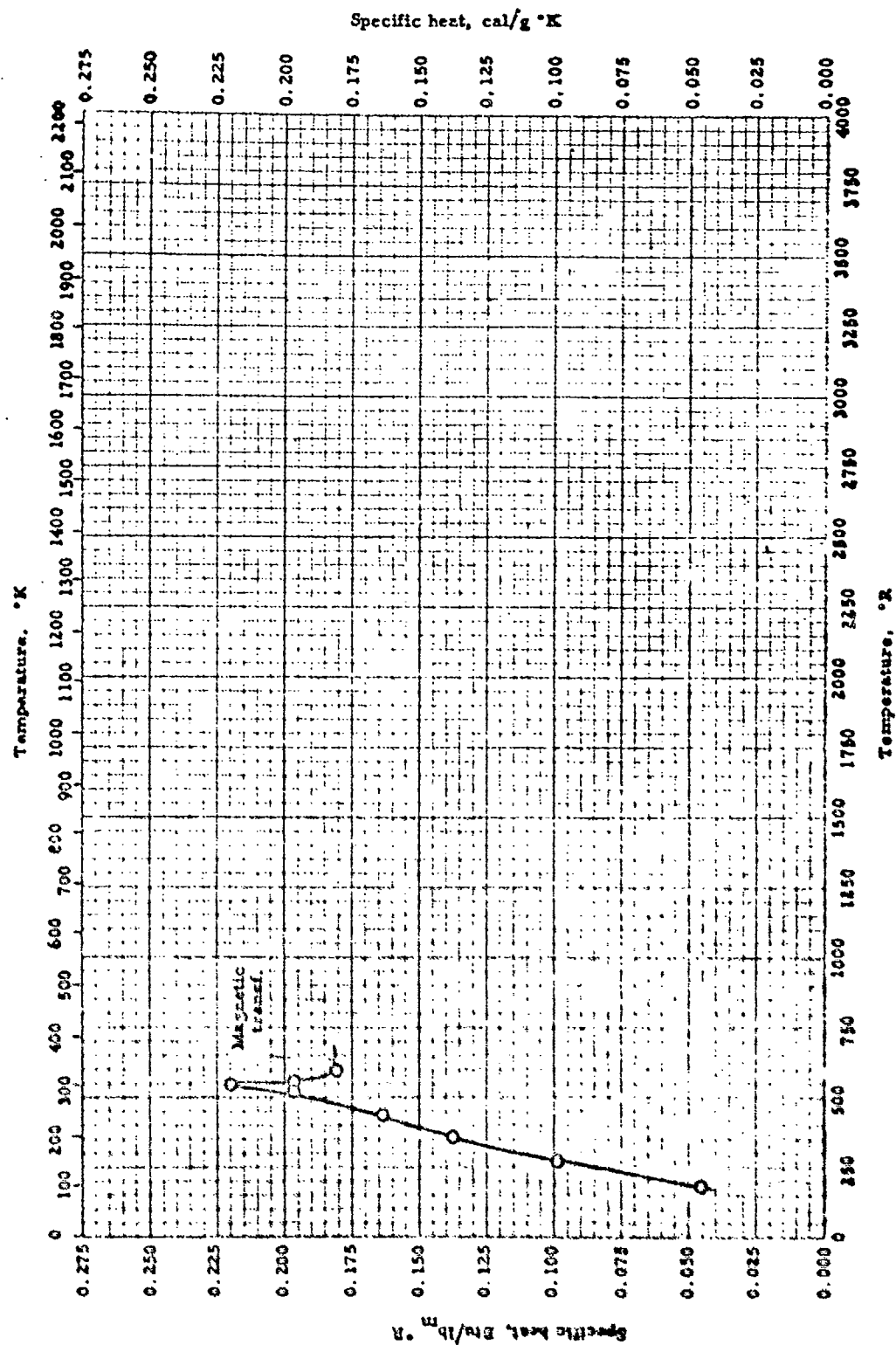
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VAPOR PRESSURE -- CADMIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O Uyeno, K.	41-5	1806-1896	CdO	Not described here; refers to others	

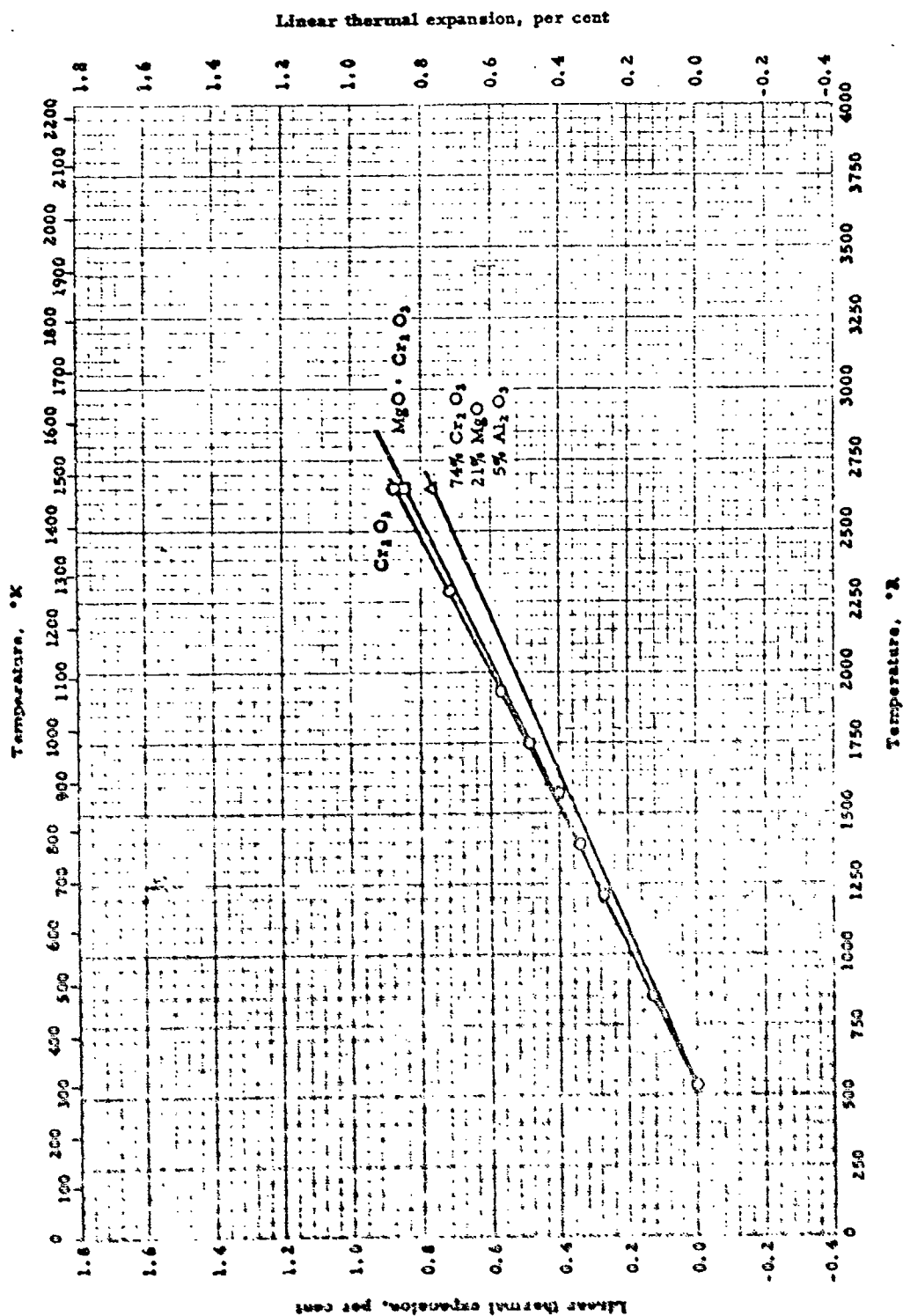


SPECIFIC HEAT -- CHROMIUM OXIDE

SPECIFIC HEAT -- CHROMIUM OXIDE

REFERENCE INFORMATION

Q	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Volger, J.	52-54	180-630	Cr ₂ O ₃	Guarded sample	Prepared by firing ammonium dichromate in air at 1000°C, formed solid pieces

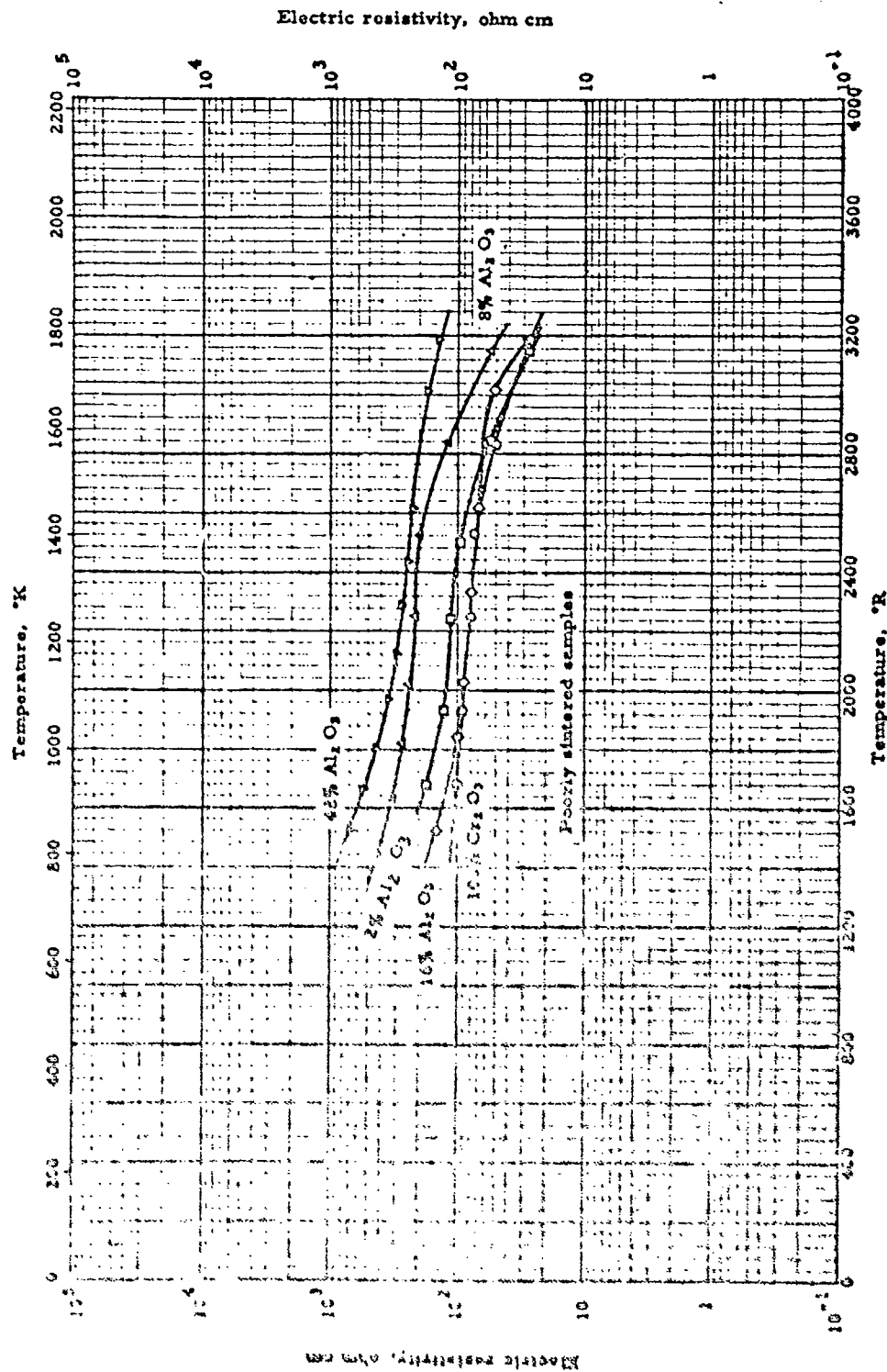


LINEAR THERMAL EXPANSION -- CHROMIUM OXIDE + X

LEUCAN THERMAL EXPANSION -- CHROMIUM OXIDE + X

REFERENCE INFORMATION

Source	Temp., °C	Material Composition	Test Method	Remarks
1. Y. G. R., Lehigh, G. H. B., and G. R. A. T.	43-8	Cr ₂ O ₃ . p = 326 lb./in. ²	Not given	Heated at 4°C/min.
2. P. G. R., Lehigh, G. H. B., and G. R. A. T.	43-14	100% Cr ₂ O ₃ 7% Cr ₂ O ₃ ; 21% MgO	Not described here, re- fers to others	Same as above
3. D. G. R., Lehigh, G. H. B., and G. R. A. T.	43-14	70% Cr ₂ O ₃ ; 21% MgO; 8% Al ₂ O ₃	Same as above	Same as above

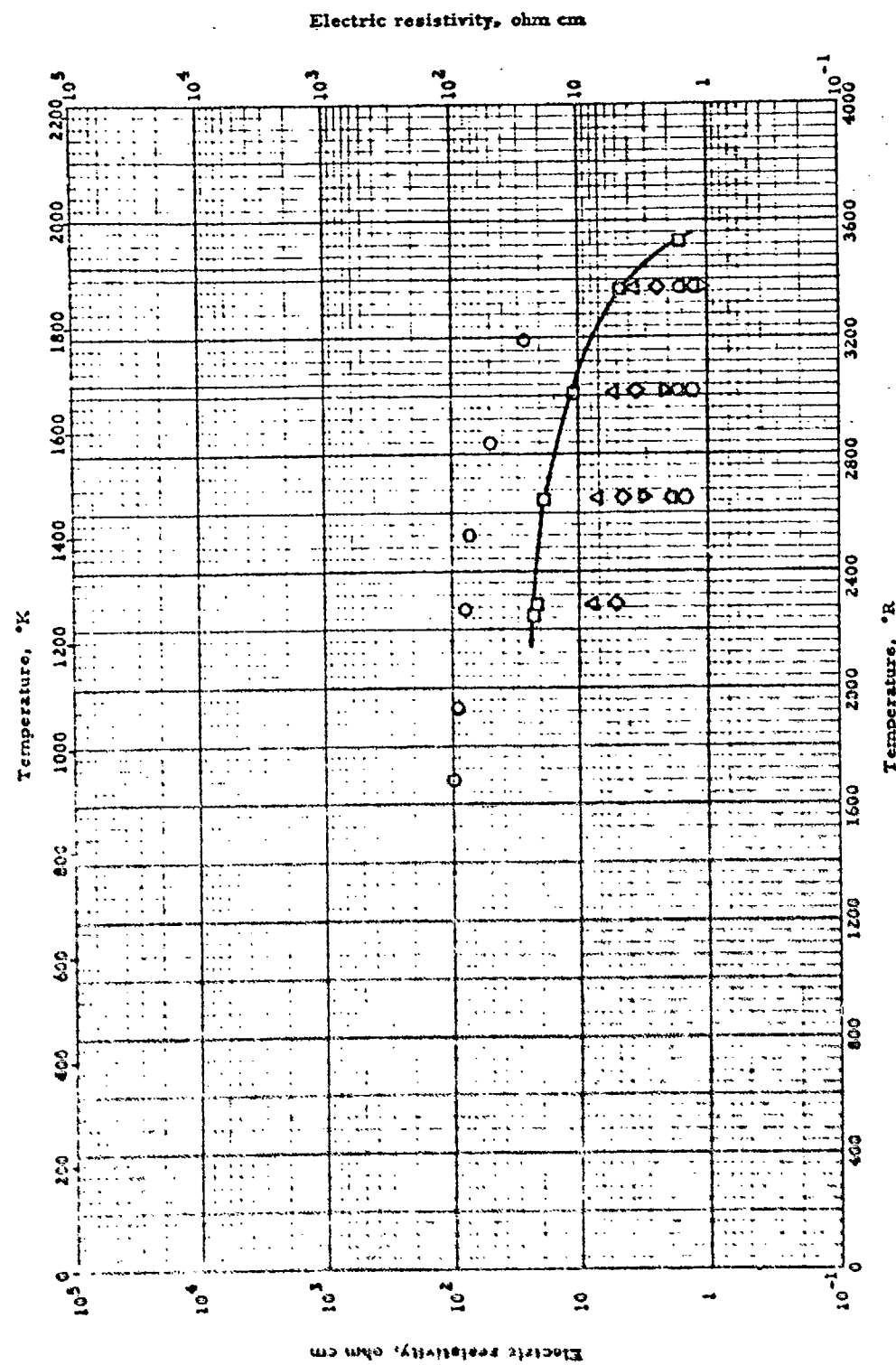


ELECTRIC RESISTIVITY -- CHROMIUM OXIDE + ALUMINA

ELECTRIC RESISTIVITY -- CHROMIUM OXIDE + ALUMINA

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
C	Heister, J. E. and Berry, E. C.	33-95	1620-3192	100% Cr ₂ O ₃	Wheatstone bridge	Fired 10 hr. to 1500°C. Poorly sintered
□	D.A.	33-95	1680-3150	95% Cr ₂ O ₃ ; 5% Al ₂ O ₃	Same as above	Same as above
Δ	D.A.	33-95	1646-3150	92% Cr ₂ O ₃ ; 8% Al ₂ O ₃	Same as above	Same as above
◇	D.A.	33-95	1518-3192	84% Cr ₂ O ₃ ; 16% Al ₂ O ₃	Same as above	Same as above
▽	D.A.	33-95	1518-3192	52% Cr ₂ O ₃ ; 48% Al ₂ O ₃	Same as above	Same as above

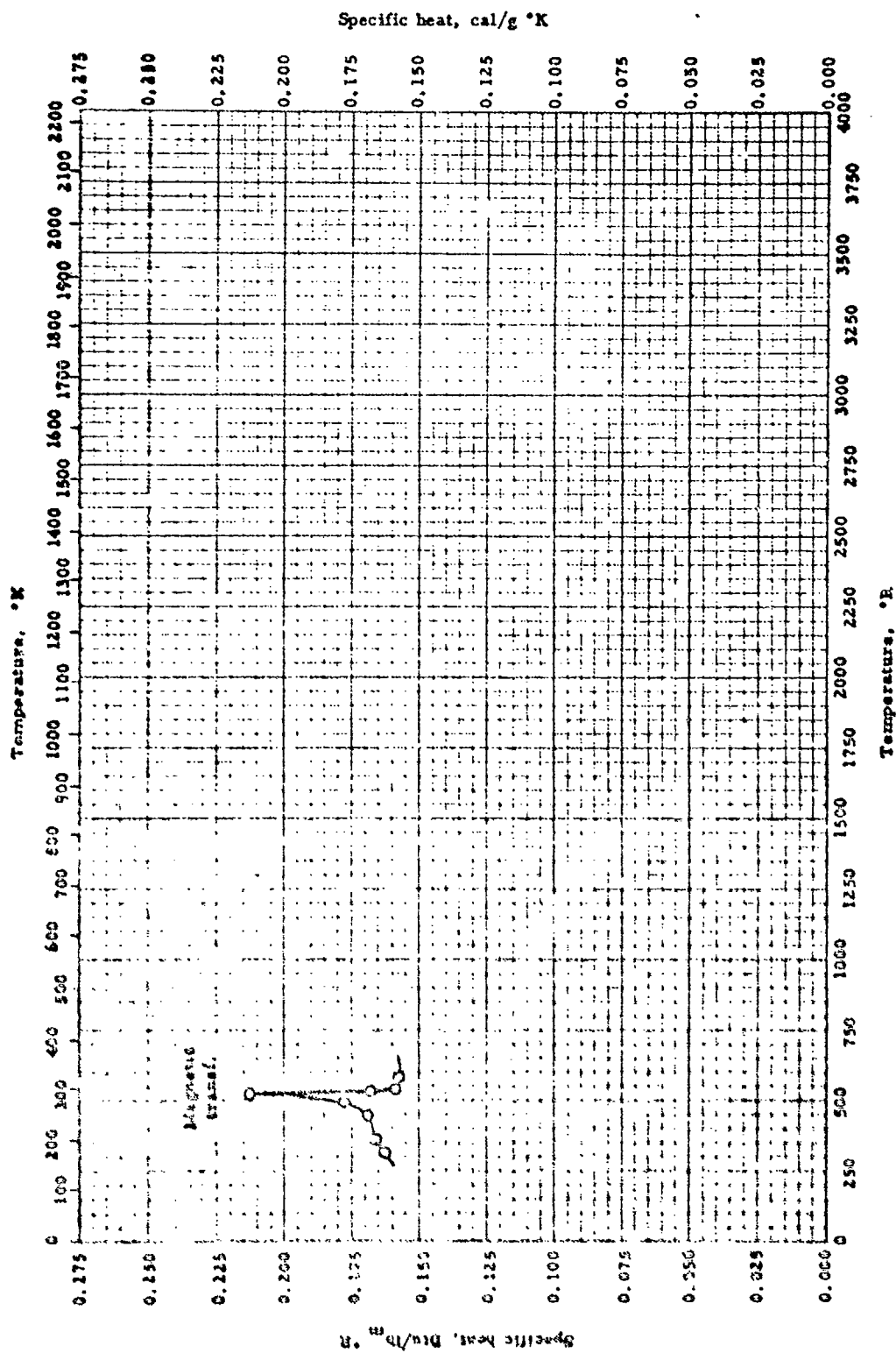


ELECTRIC RESISTIVITY -- CHROMIUM OXIDE

ELECTRIC RESISTIVITY -- CHROMIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Wentley, J. R. and Lacey, E. C.	23-55	1680-3192	"100% Cr ₂ O ₃ "	Wheatstone bridge	Fired at 1450°C for 10 hrs, "poorly sintered"
Fincher, W. A. and Lacey, G.	57-177	2250-3530	Water free; 0.5% alloyed; 0.055% Fe; 0.037% Ca; 0.023% Mg; 0.010% Si; no trace Al	A. C. bridge (50 am 1000 cycles)	Presintered 1 hr. at 1500°C in argon atmos. Results independent of frequency
D.L.	57-177	2292-3372	Same as above + 0.9% Cu ₂ O	Same as above	Same as above
L.H.	57-177	2292-3372	Same as □ + 2.6% Nb ₂ O ₅	Same as above	Same as above
D.H.	57-177	2632-3372	Same as □ + 0.5% TiO ₂	Same as above	Same as above
D.H.	57-177	2632-3372	Same as □ + 0.7% TiO ₂	Same as above	Same as above
D.H.	57-177	2632-3372	Same as □ + 2.4% NiO	Same as above	Same as above

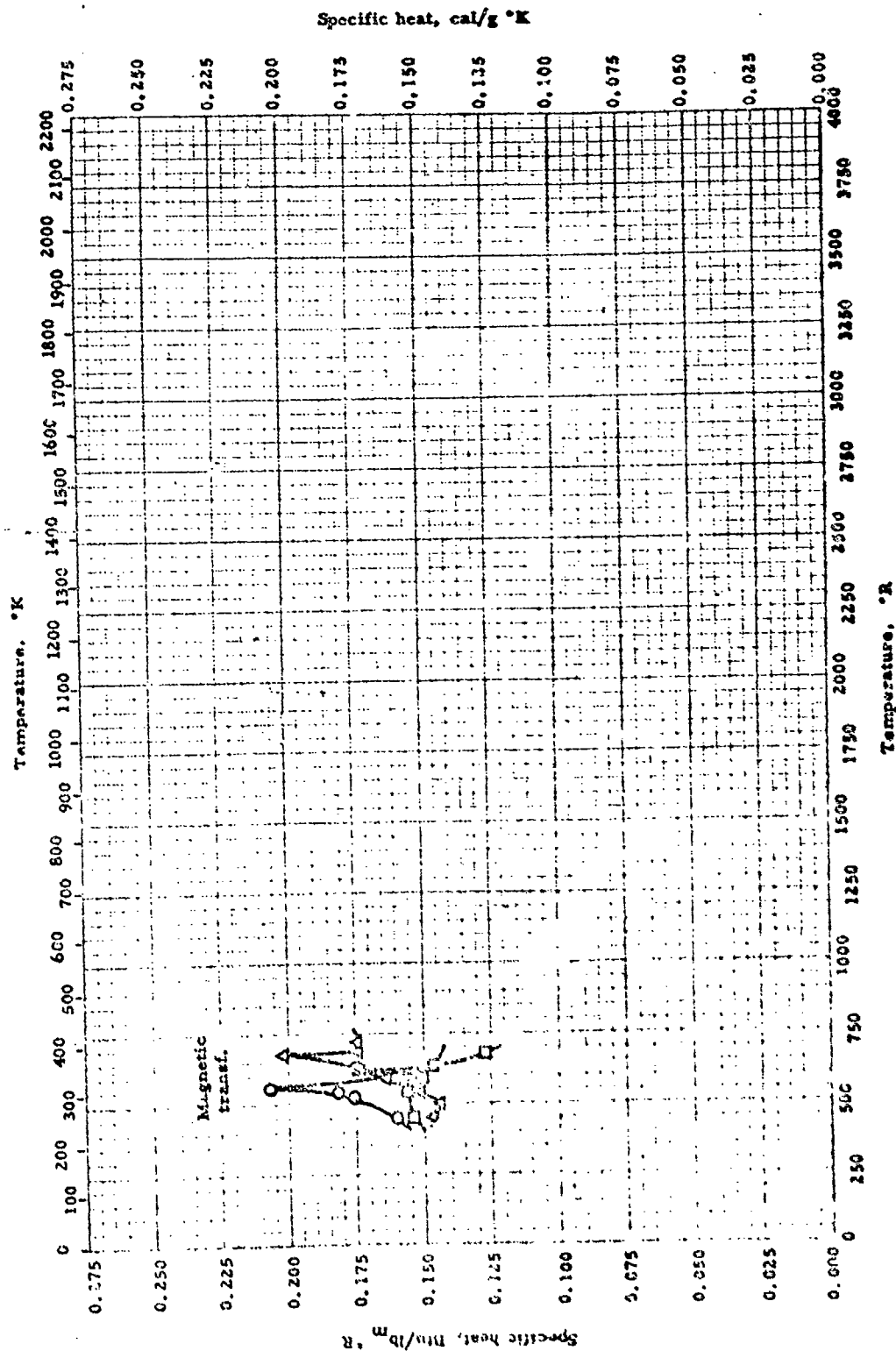


SPECIFIC HEAT -- CoO - CuO INVERSE SPINEL

SPECIFIC HEAT -- CoO-CuO INVERSE SPINEL

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
54-58	Asayag, G. and Borelle, H.	54-58	115-285	91.24% CoO; 8.76% CuO	Comparative, rate of temp. rise in sample compared with standards (Al ₂ O ₃ and benzoic acid) under same heating con- ditions	91.7 mol % CoO; 8.3 mol % CuO. Main purpose of article is to show the anom- aly due to magnetic sus- ceptibility (289.7°K)



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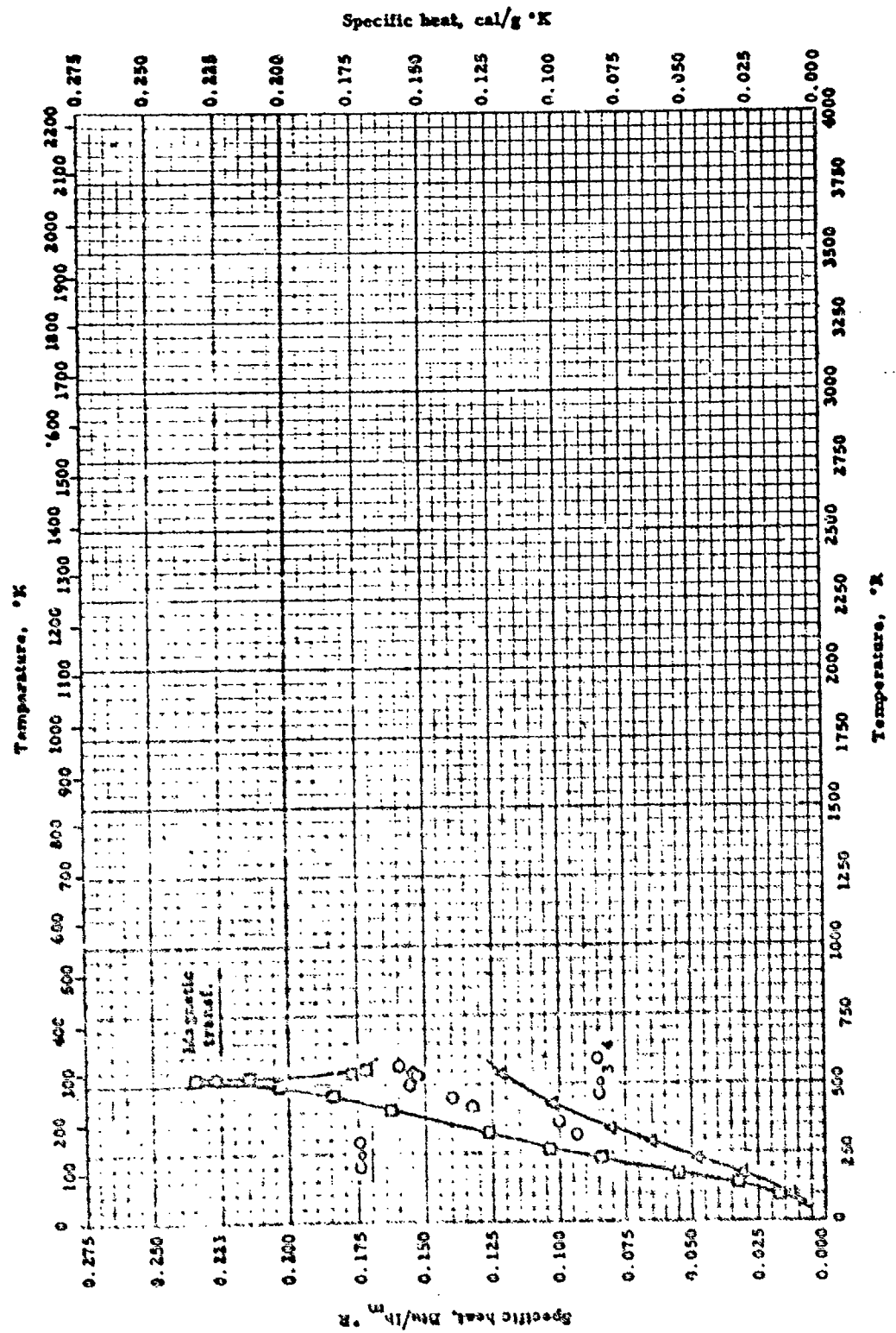
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SPECIFIC HEAT -- CoO-NiO INVERSE SPINEL

SPECIFIC HEAT -- CoO-NiO INVERSE SPINEL

REFERENCE INFORMATION

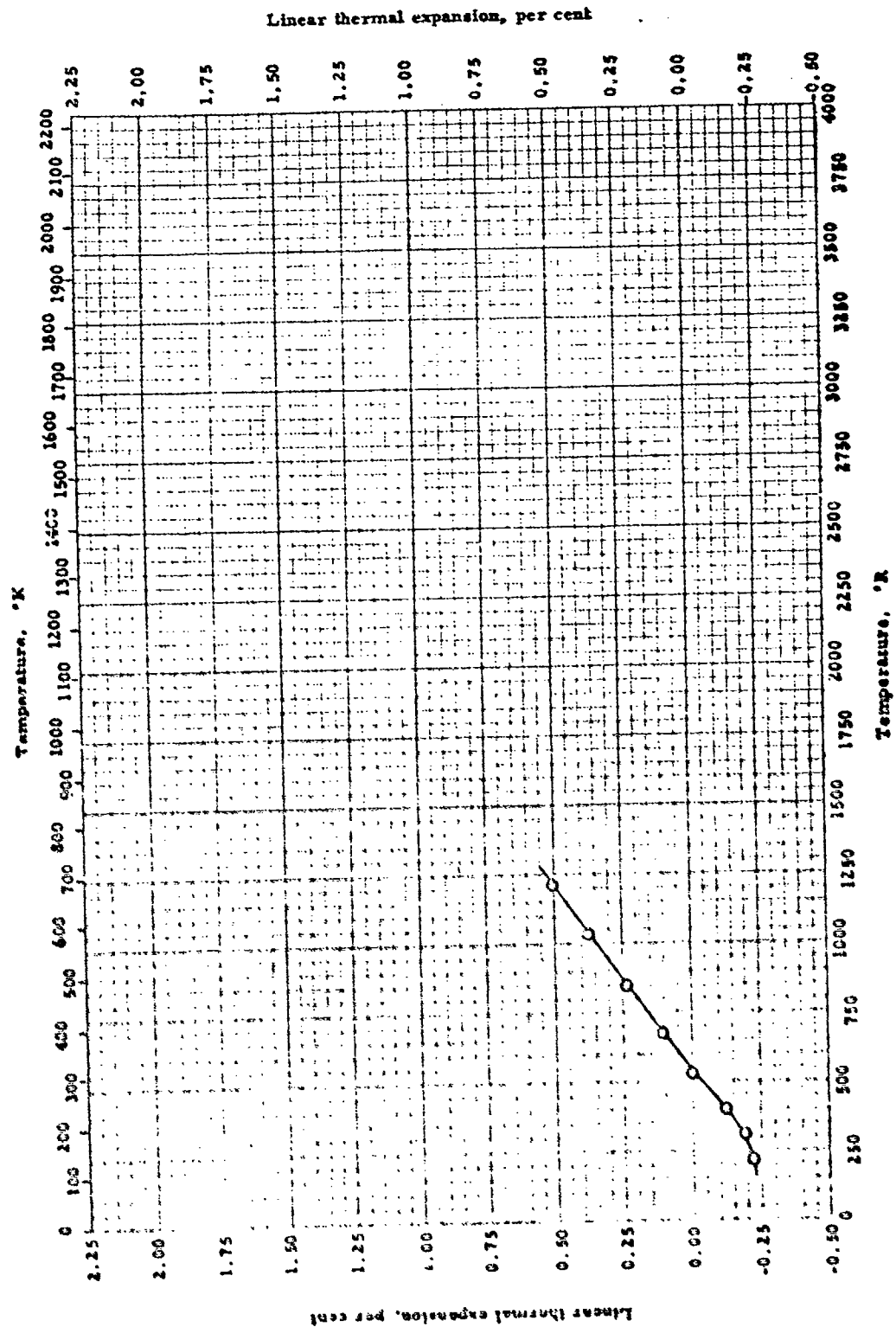
Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
14-58	Reay, G. and Disanto, H.	450-630	50.03% CoO; 9.97% NiO	Comparative, rate of temp. rise in sample compared with standards (Al ₂ O ₃ and benzoic acid) under same heating con- ditions	90 mol % CoO; 10 mol % NiO. Main purpose of article is to show the anom- aly due to magnetic sus- ceptibility (311 °K)
54-58	Did.	450-678	75.66% CoO; 24.94% NiO	Same as above	75 mol % CoO - 25 mol % NiO. Purpose same as above (345 °K)
54-58	Did.	450-720	59.98% CoO; 40.02% NiO	Same as above	59.9 mol % CoO; 40.1 mol % NiO. Purpose same as above (376.7 °K)



SPECIFIC HEAT -- COBALT OXIDE

REFERENCE INFORMATION

No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Assyng, G. and Elberts, H.	54-58	315-555	CoO	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	Prepared from recrystallized reagent grade cobaltous sulfate heptahydrate
2	King, E. G.	57-41	97-554	CoO; 78.61% Co	Guarded sample	Prepared from recrystallized reagent grade cobaltous sulfate heptahydrate
4	Dud.	57-41	97-554	Co ₃ O ₄	Same as above	Prepared from recrystallized reagent grade cobaltous sulfate heptahydrate



LINEAR THERMAL EXPANSION -- COBALT OXIDE

LINEAR THERMAL EXPANSION -- COBALT OXIDE

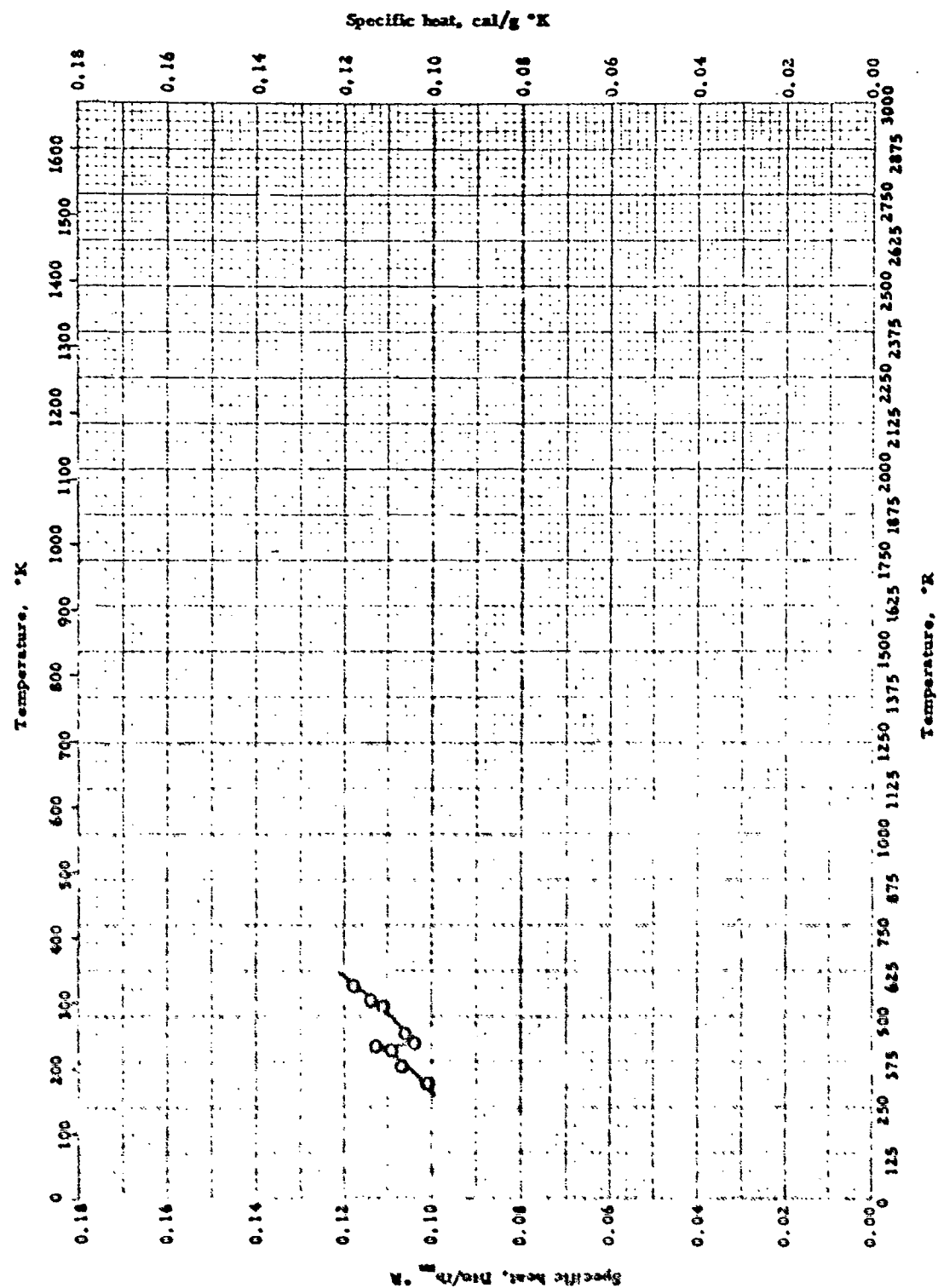
REFERENCE INFORMATION

No.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	Foss, M.	48-5	222-1212	CoO	Dilatometer	N ₂ atmos.

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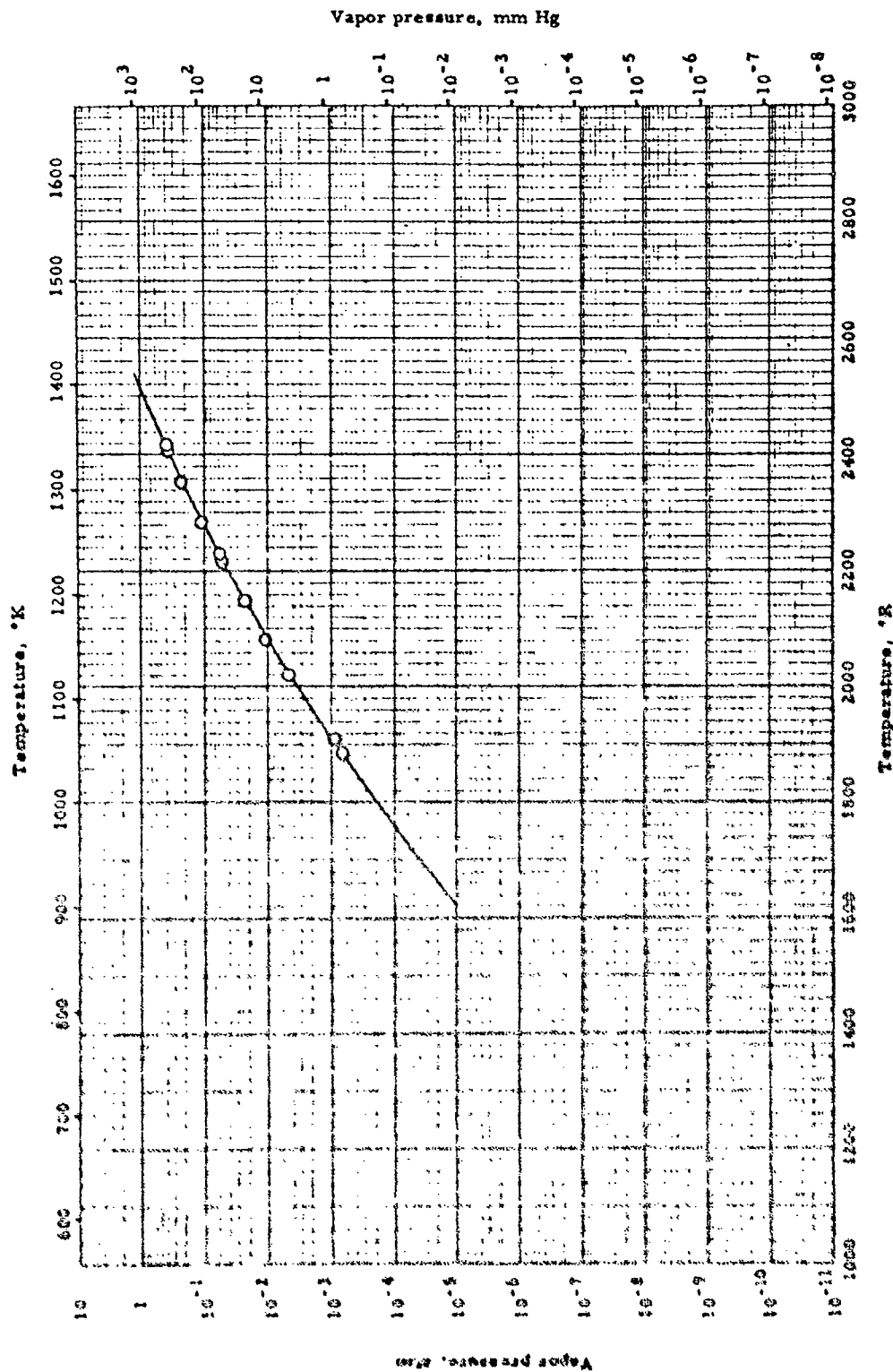
Specific heat -- ORDER CYME

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SPECIFIC HEAT -- COPPER OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Assay, G. and Dibette, H.	54-58	325-585	CuO	Comparative; rate of temp. rise in sample compared with standard under same heating con- ditions	

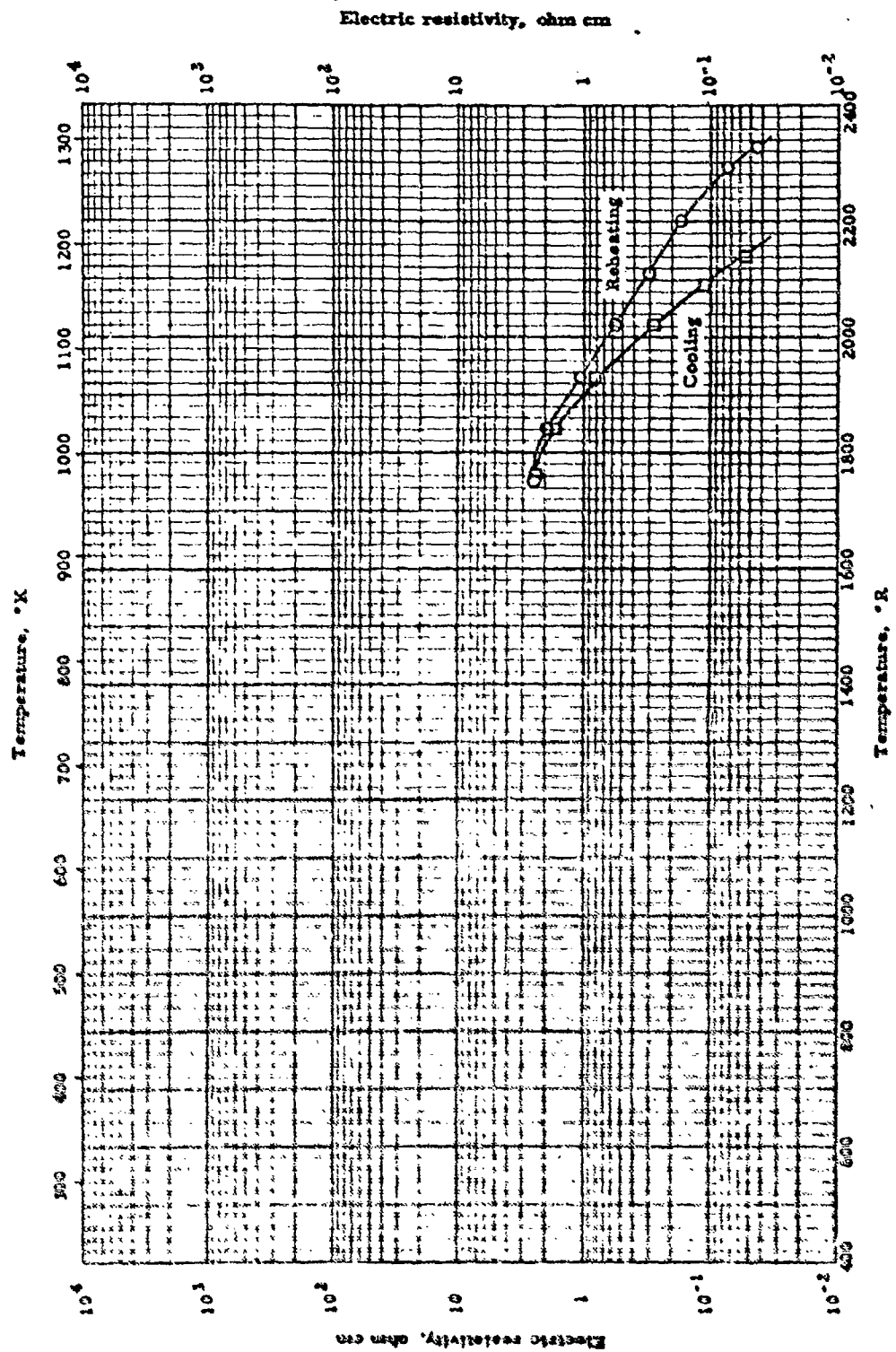


VAPOR PRESSURE -- COPPER OXIDE

VAPOR PRESSURE -- COPPER OXIDE

REFERENCE INFORMATION

I	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Assay, P.	55-63	1835-2416	CuO	McLeod Gauge up to 20mm Hg; Hg manometer above 20mm Hg	

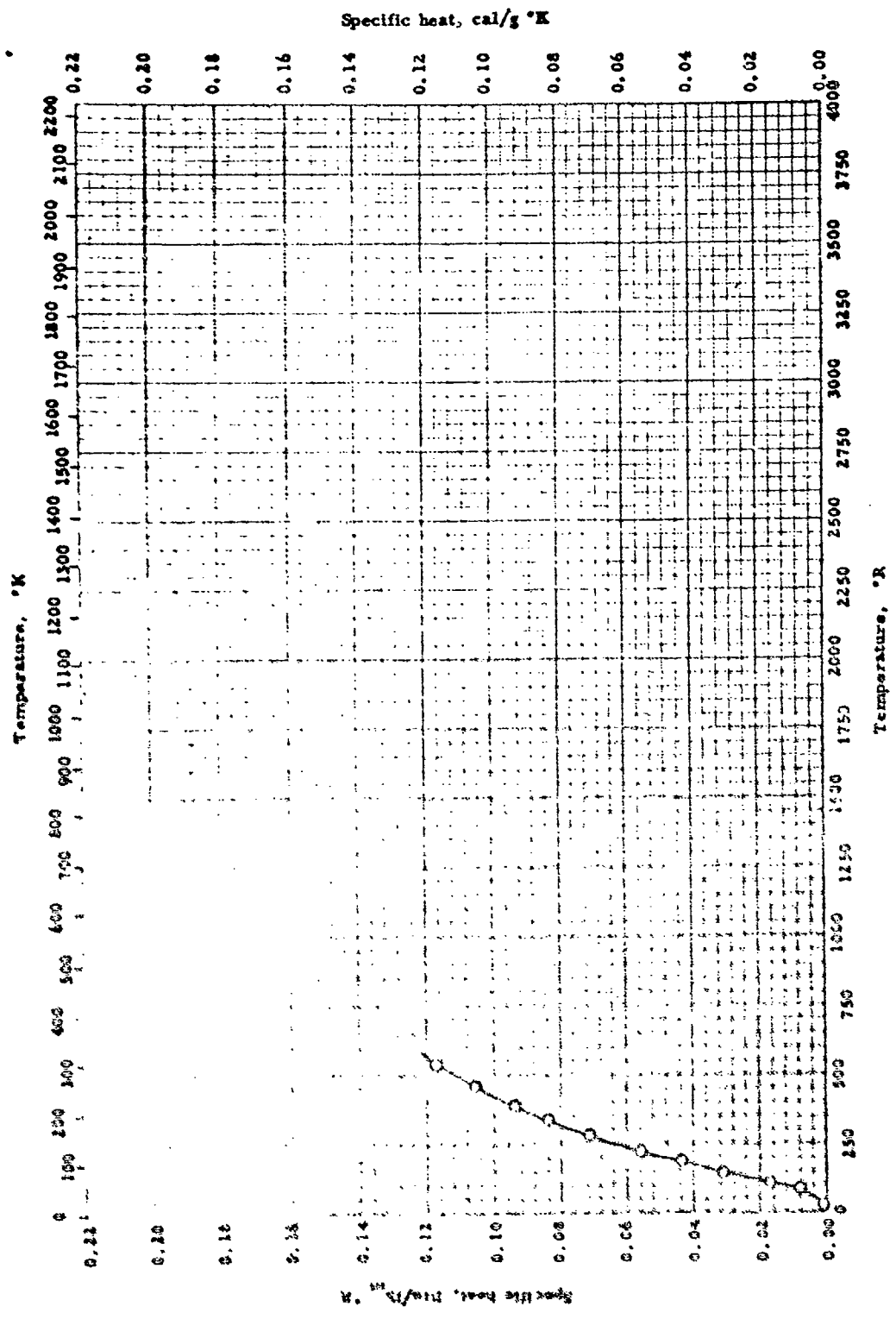


ELECTRIC RESISTIVITY -- COPPER OXIDE

ELECTRIC RESISTIVITY -- COPPER OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
F. A. O. A. and Z. A. A. V. L.	57-108	1752-2292	CuO; Russian brand Ch. D. A.	1000 cycles resistance bridge	Reheating Cooling
Li	57-108	1752-2292	Same as above	Same as above	



SPECIFIC HEAT -- GALLIUM OXIDE

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NACA TR 54-476 329

SPECIFIC HEAT -- GALLIUM OXIDE

REFERENCE INFORMATION

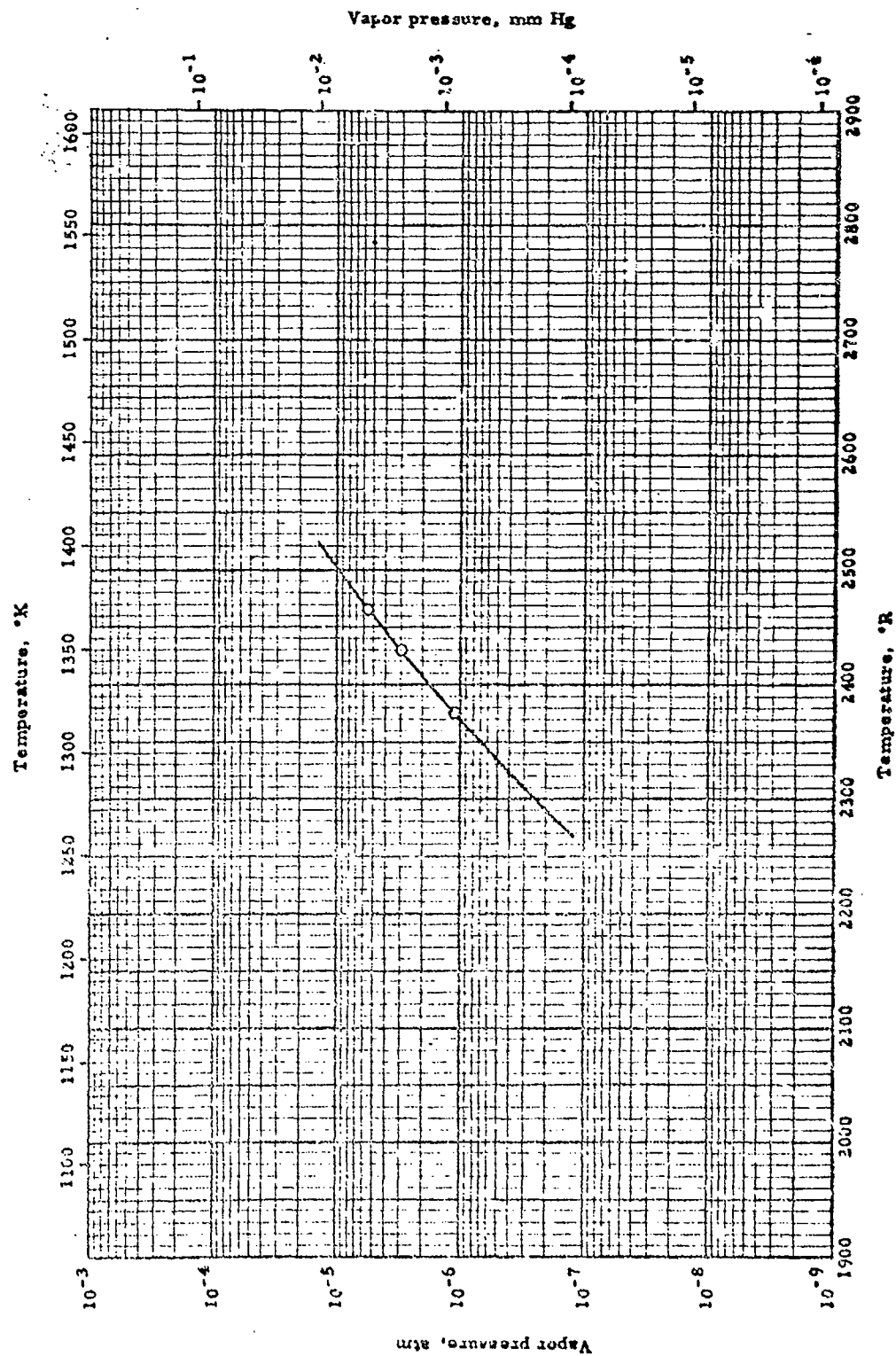
Investigator	Ref.	Temp., °K	Material Composition	Test Method	Remarks
Adams, Jr., G. G. and Johnson, M. L.	52-57	22-540	92.67% Ga - Ga ₂ O ₃ ; 1.16% SiO ₂ ; 0.1% ZnO; 0.05% ea. Fe ₂ O ₃ , Al ₂ O ₃ ; 0.02% SnO; 0.01% MgO; 0.008% CuO; 0.001% ea. V ₂ O ₅ , MnO ₂ , PbO, MnO	Guarded sample	Corrected for impurities

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VAPOR PRESSURE -- GERMANIUM OXIDE

VAPOR PRESSURE -- GERMANIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O Shimazaki, E., and Mitsumoto, N. and N'wa, K.	57-64	2376-2466	99.99% pure GeO ₂	Knudsen effusion cell	Auth. notes dissociation of GeO ₂ into GeO + 1/2 O ₂ in gas phase

PROPERTIES OF IRON OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, Magnetite . . .	314 lb _m /ft ³	5.03 g/cm ³
Melting Point, Magnetite .	3260°R*	1811°K*
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
O	314	5.03
□	313	5.01
Δ	316	5.06

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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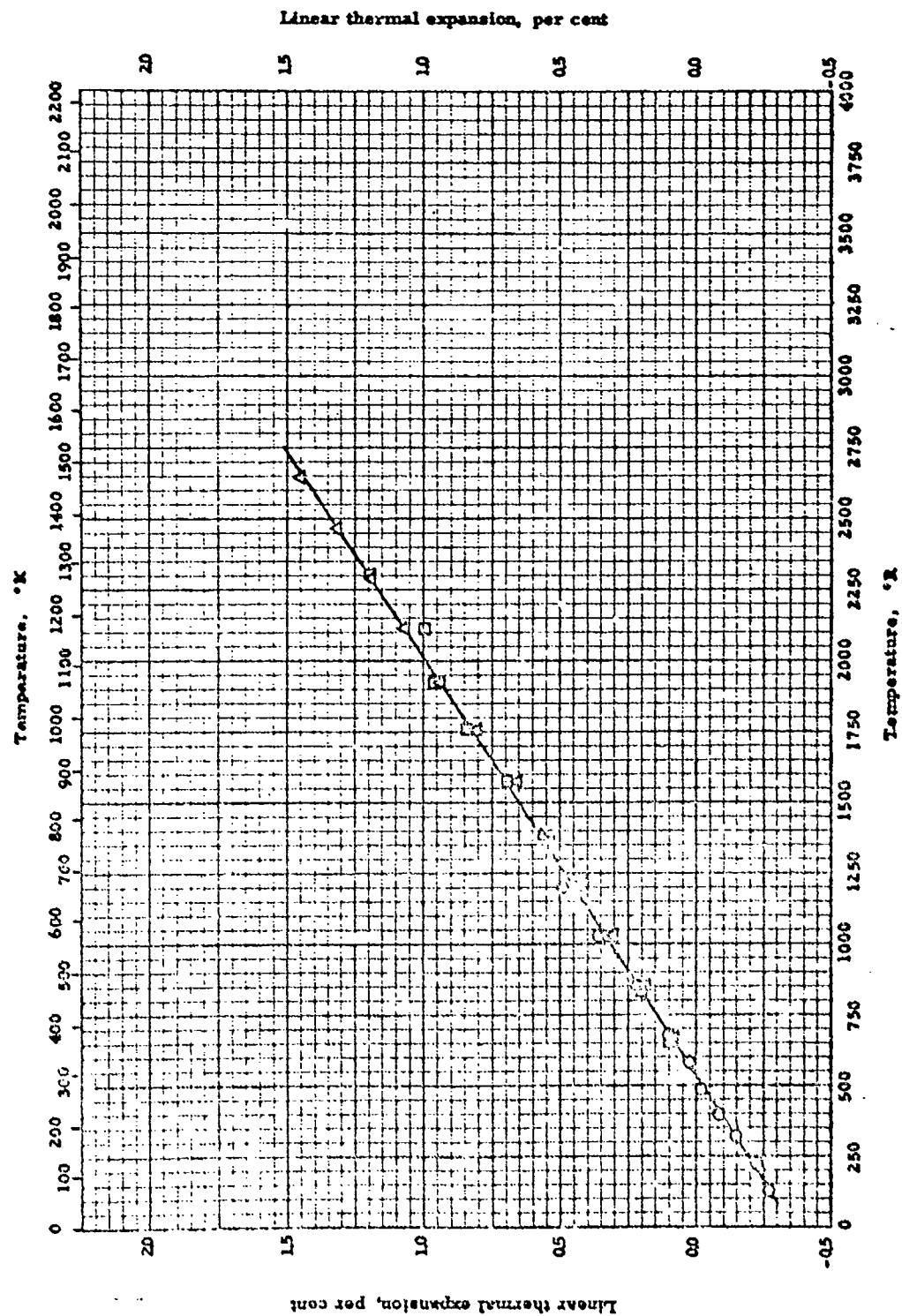
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF IRON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Economos, G.	55-145	Room	Magnetite, Fe_3O_4	p: displacement in acetone	Prepared from high purity iron oxide heated 5 hrs. at 800°C in platinum crucibles; firing atmos. of CO-CO ₂
□	Ibid.	55-145	Room	Same as above	p: same as above	Same as above with firing atmos. of CO ₂
△	Ibid.	55-145	Room	Same as above	p: same as above	Same as above with firing atmos. of He



LINEAR THERMAL EXPANSION -- IRON OXIDE

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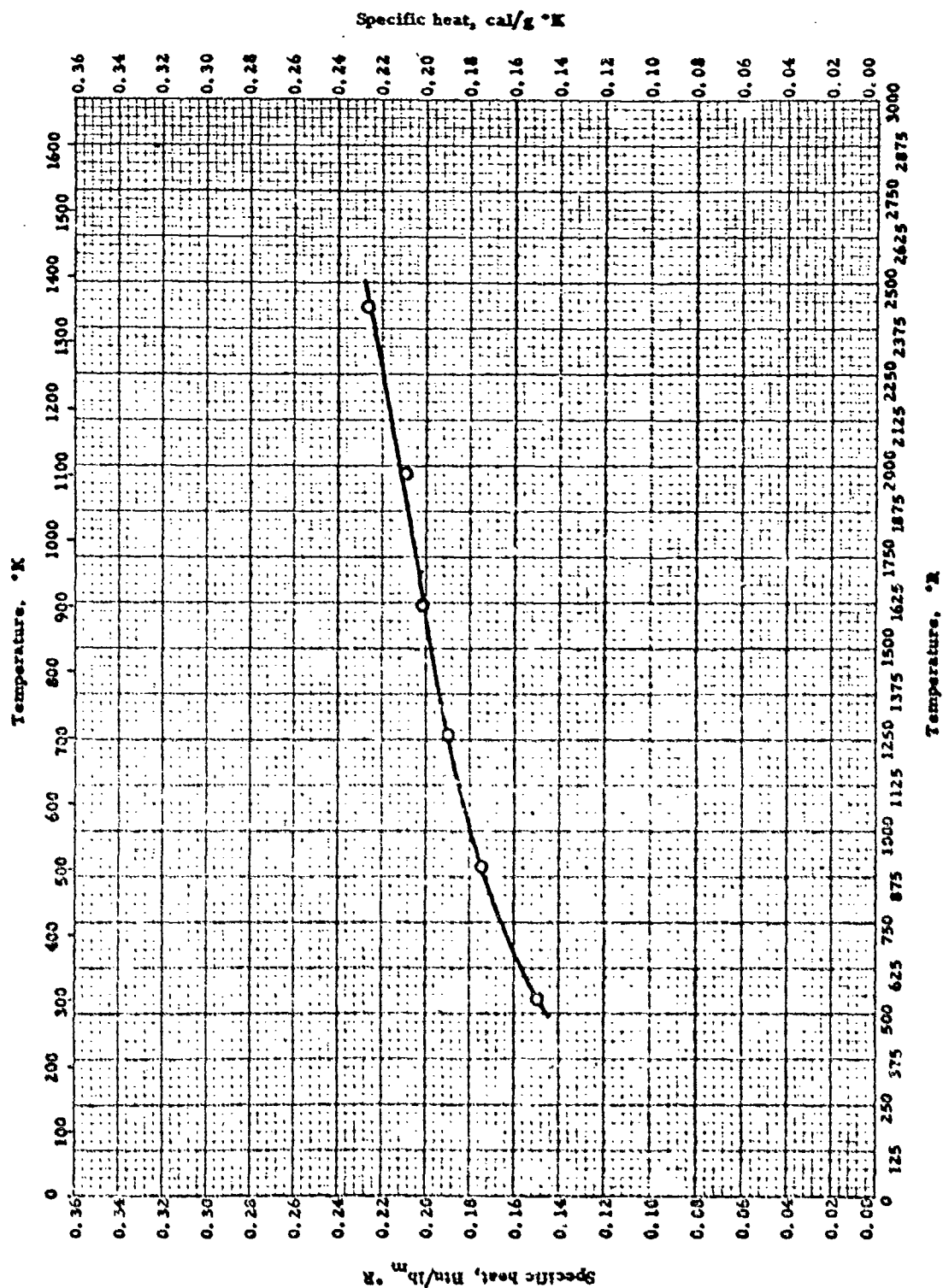
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LINEAR THERMAL EXPANSION -- IRON OXIDE

REFERENCE INFORMATION

Sym Eol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Foex, M.	43-5	132-1212	FeO	Dilatometer	N ₂ atmos.
□	Rigby, G. R. Lovell, G. H. Green, A. T.	46-8	672-2472	90% FeO; $\rho = 346 \text{ lb}_m/\text{ft}^3$	Not given	
Δ	Ibid.	46-8	672-2652	Fe ₂ O ₃ ; $\rho = 326 \text{ lb}_m/\text{ft}^3$	Same as above	



SPECIFIC HEAT -- MANGANESE OXIDE

SPECIFIC HEAT -- MANGANESE OXIDE

REFERENCE INFORMATION

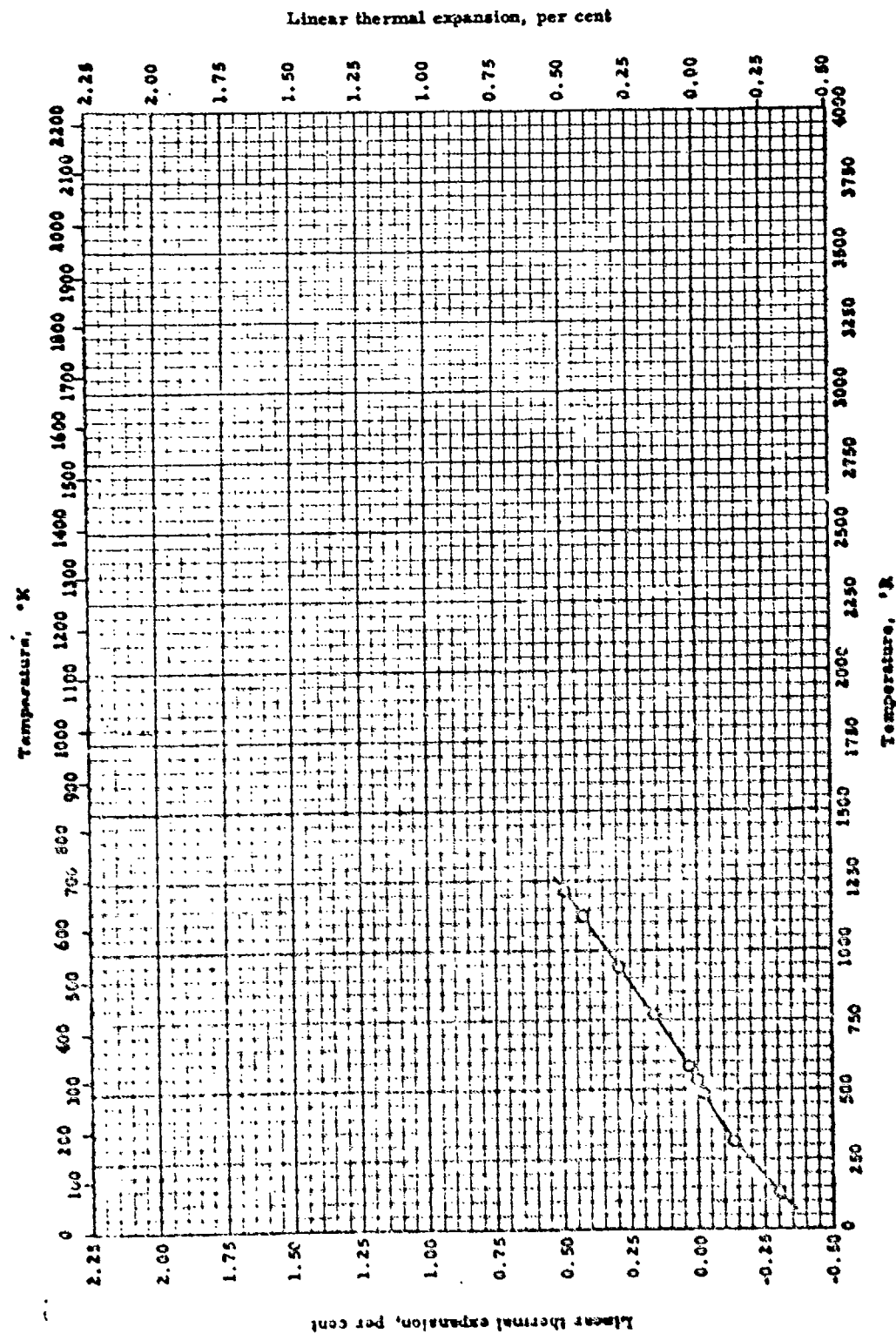
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Orr, R. L.	54-135	540-2430	Mn ₂ O ₃ , manganese sesquioxide; 69.64% Mn; 10.19% O	Drop method	c _p calc. from $C_p \left(\frac{\text{cal}}{\text{g-mole} \cdot ^\circ\text{K}} \right) = 24.73$ $+ 8.38T - 3.23 \times 10^{-5} T^2$ (T in °K); mean deviation of enthalpy points from this eq. is $\leq 0.2\%$.

54-830

WADC TR 58-476

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LINEAR THERMAL EXPANSION -- MANGANESE OXIDE

LINEAR THERMAL EXPANSION -- MANGANESE OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Foer, M.	48-5	122-1212	MnO	Dilatometer	N ₂ atmos.

PROPERTIES OF MOLYBDENUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	281 lb _m /ft ³ *	4.5 g/cm ³ *
Melting Point.	1923 °R	1068 °K
Heat of Fusion.	157 Btu/lb _m	87 cal/g
Heat of Vaporization.		
Heat of Sublimation.	319 _{1530°R} Btu/lb _m	177 _{850°K} cal/g

* Handbook of Chemistry and Physics (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
 □ 1923.1 1068.4

Heat of Fusion: Btu/lb_m cal/g
 Q 156.6 87.1

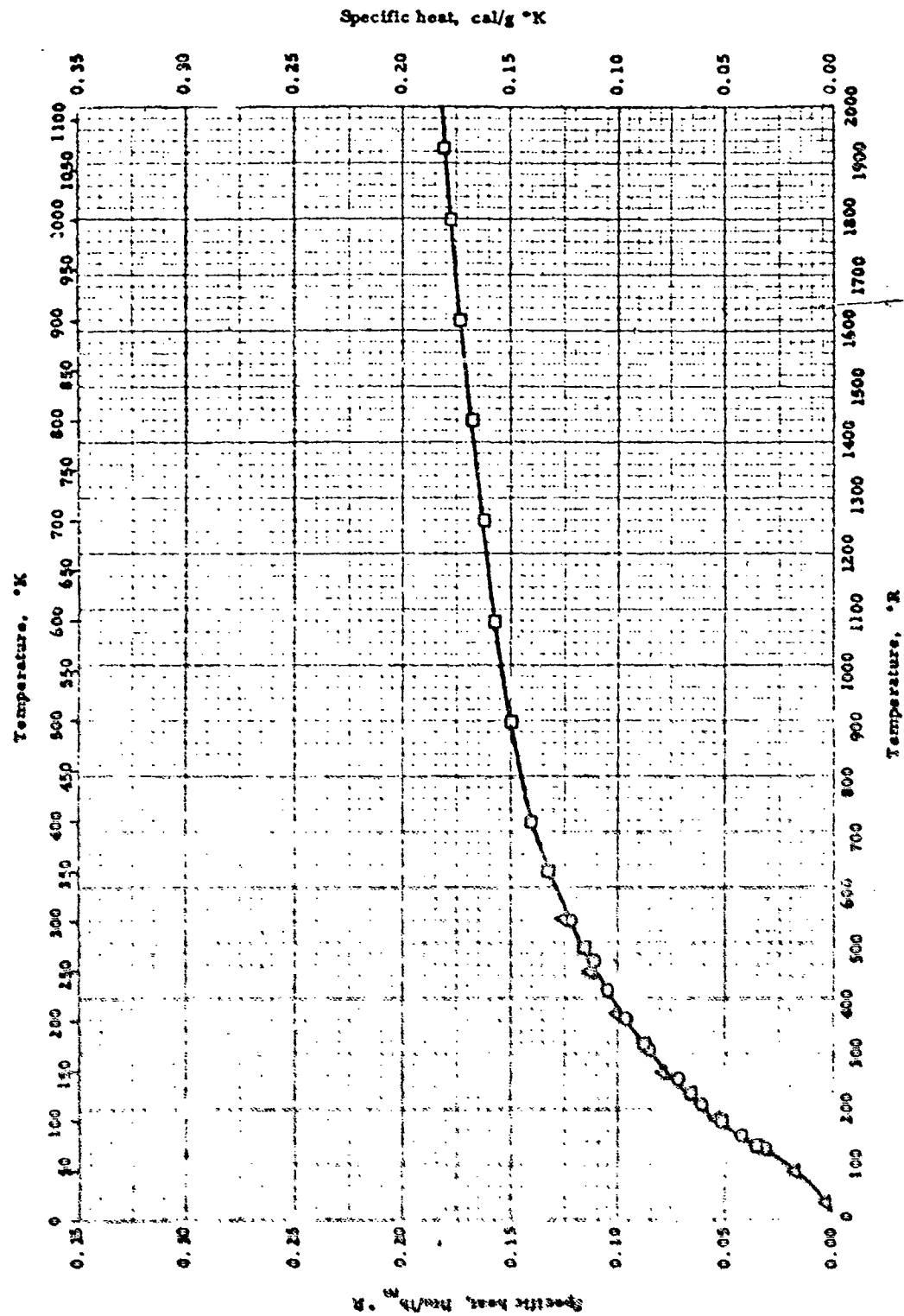
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g
 Δ 796.5_{1671°R} 442.5_{928°K}
 ◇ 335_{1530°R ± 6} 184_{850°K ± 3}
 V 293_{1530°R ± 5} 163_{850°K ± 3}
 O 264_{1530°R ± 9} 147_{850°K ± 5}
 □ 319_{1530°R} 177_{850°K}

PROPERTIES OF MOLYBDENUM OXIDE

REFERENCE INFORMATION

Author	Ref.	Temp., °C	Material Composition	Test Method	Remarks
W. A. Pryor, L. A. and J. P. G.	11-1	1923	MoO ₃ , 44.8 ± 0.07% Mo; 55.0 ± 0.1% O ₂ based. In NH ₃ 0.43% and volatile with HCl at 450°C; spectroscopic trace of heavy metals and alkali metals	Abi drop method; ice calorimeter	Vapor pressure measured 1635-1707°K
G. A. K.	11-1	1923	Same as above	Abi; not given	
A. K.	41-3	1671	Find given	Abi; from vapor pressure data	Vapor pressure measured 1440-1600°K. Temp. measured ± 10°C
G. A. K., J. P. G., and L. A. Pryor, L. A.	ND-3	1310	Not given; vapor phase Mo ₂ O ₃	Abi; from vapor pressure data by Kauden cell with mass spectrometer; Pt, Pt-Rh thermocouple	Same as above
V. A.	ND-3	1310	Not given; vapor phase Mo ₂ O ₃	Abi; same as above	Same as above
G. A. K.	ND-3	1520	Not given; vapor phase Mo ₂ O ₃	Abi; same as above	Vapor composition determined using mass-spectrometer
G. A. K.	ND-3	1530	Not given; vapor phase 64% Mo ₂ O ₃ , 39% Mo ₄ O ₁₁ , 5% Mo ₅ O ₁₅	Abi; computed from Abi for given vapor species	

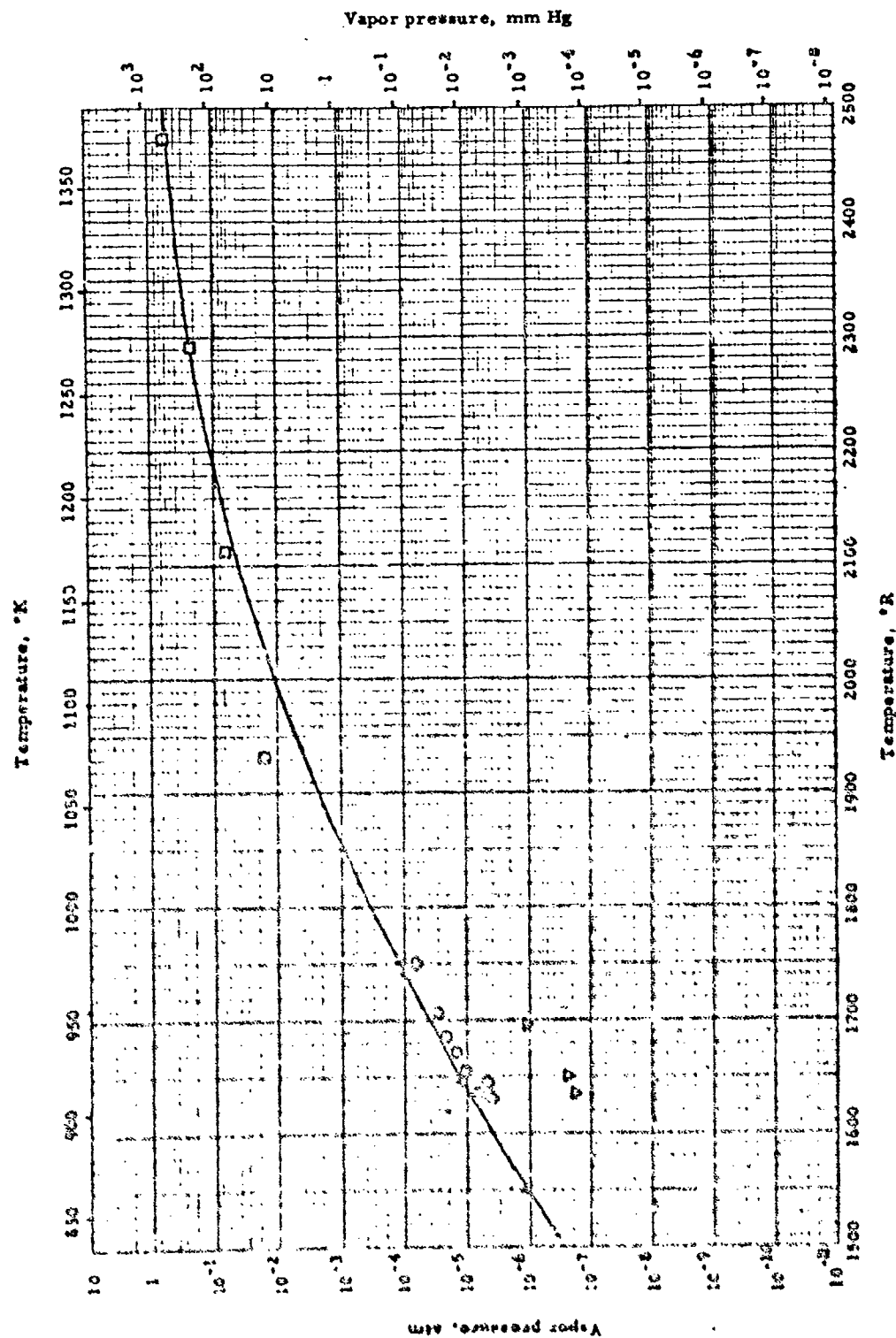


SPECIFIC HEAT -- MOLYBDENUM OXIDE

SPECIFIC HEAT -- MOLYBDENUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Allen, H., Dunbar, F. J. and Wright, B. J.	43-3	126-538	99.9% MoO ₃	Guarded sample	Small transparent rhombic crystals
2	Cragg, L. A. and Taylor, P. E.	53-1	127-2340	MoO ₃ 66.8 ± 0.07% assayed Mo; 9.961% insoluble in NH ₃ ; 0.005% non-volatile with HCl at 450°C; spectroscopic trace of heavy metals and alkali metals	Drop method; ice calorimeter	Extrapolation to low temp. by method of Debye and Einstein
3	Smith, D. F. Brown, D. et al.	56-150	16-940	MoO ₃ C.P. grade	Low temperature adia- batic calorimeter	

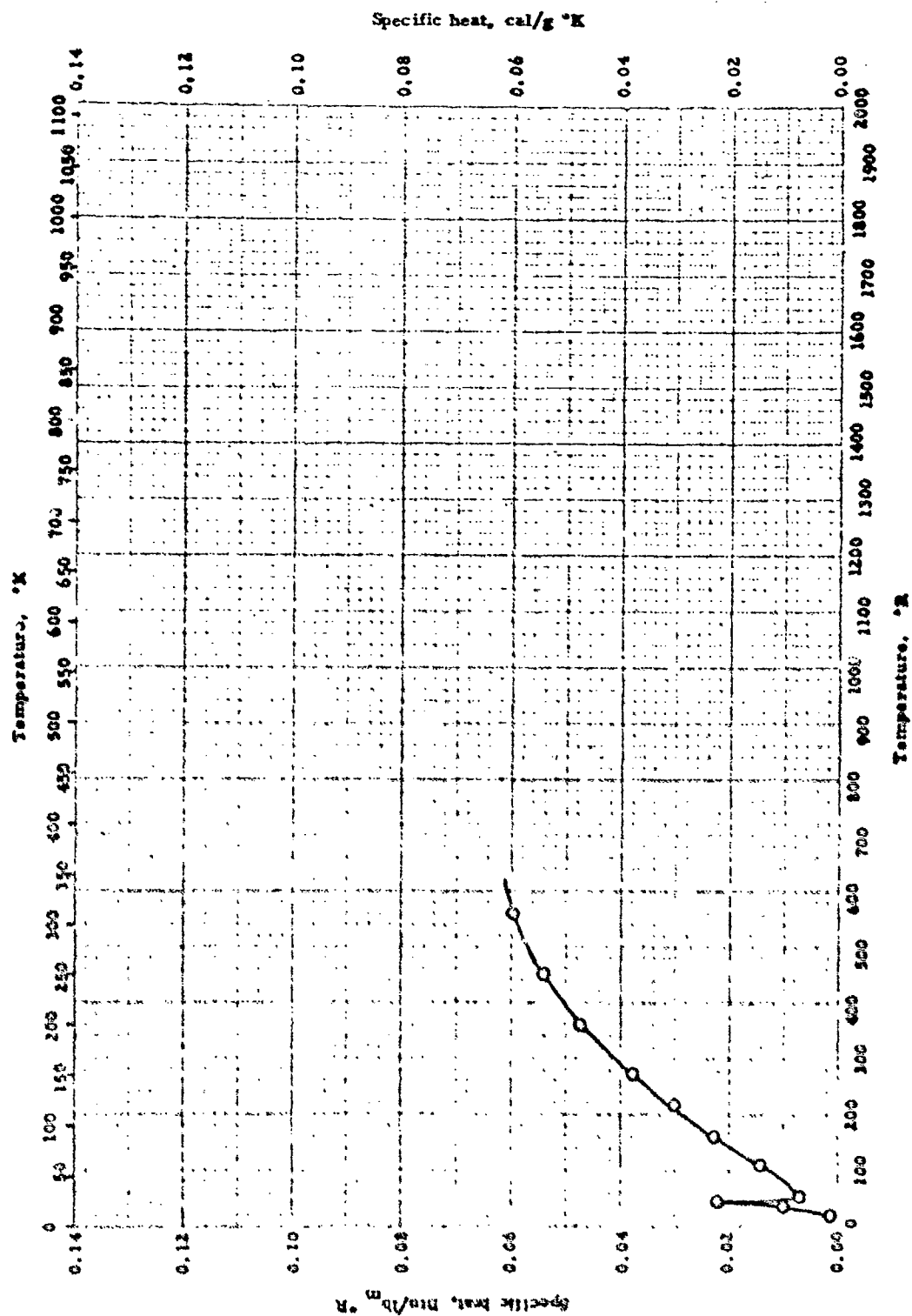


VAPOR PRESSURE -- MOLYBDENUM OXIDE

VAPOR PRESSURE -- MOLYBDENUM OXIDE

REFERENCE INFORMATION

	Inventor, mox	Ref.	Pat. No., R.	Material Composition	Test Method	Remarks
1	Uyeno, K.	41-5	1635-1707	MoO_3	Not given here; refers to others	
2	Zel'nerman, A. N., Gorvits, H. M., and Prasachova, T. E.	55-C	1922-2472	Chemically "pure" MoO_3	Boiling points at fixed pressures	
3	Bartholomew, J., Egbertson, M. G., and Campbell, W. A.	ND-1	1550-1731	Mo_2O_5 vapor over MoO_3	Knudsen effusion cell, mass spectrometer	
4	Ida	ND-1	1619-1751	Mo_4O_{12} vapor over MoO_3	Same as above	
5	Ida	ND-1	1634-1697	Mo_5O_{15} vapor over MoO_3	Same as above	

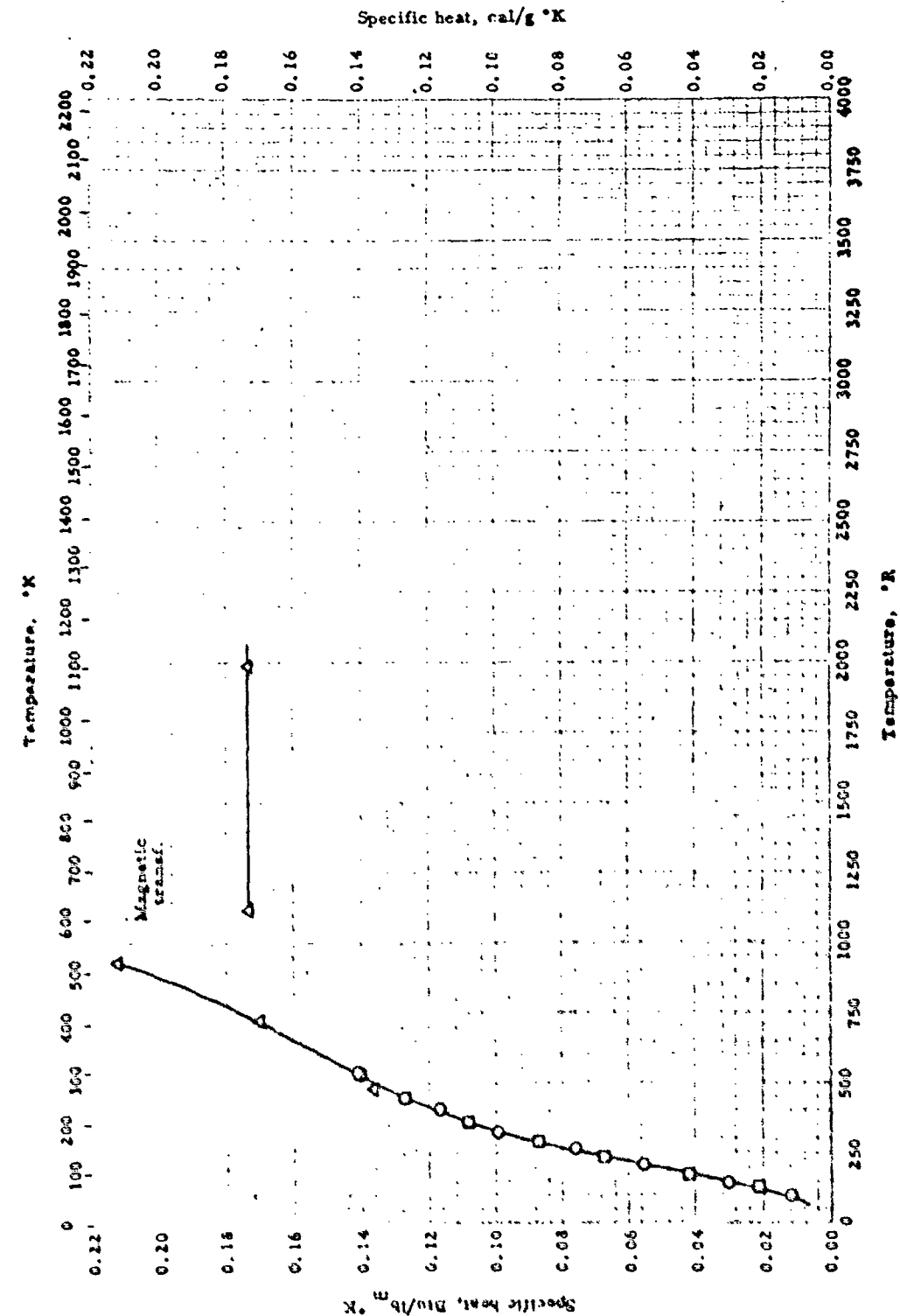


SPECIFIC HEAT -- NEPTUNIUM OXIDE

SPECIFIC HEAT -- NEPTUNIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Westrum, Jr., E. F., Hatcher, J. D. and Osborne, D. W.	53-58 also 50-21	20-558	99.94% pure NpO_2 ; <0.1% total Cr, Fe, Ca	Guarded sample	Np^{237} prepared by U^{238} (n,2n) U^{237} β^- Np^{237} Hydroxide precipitated from acid solution and ignited to constant wt. in air in Pt boat at 700°C

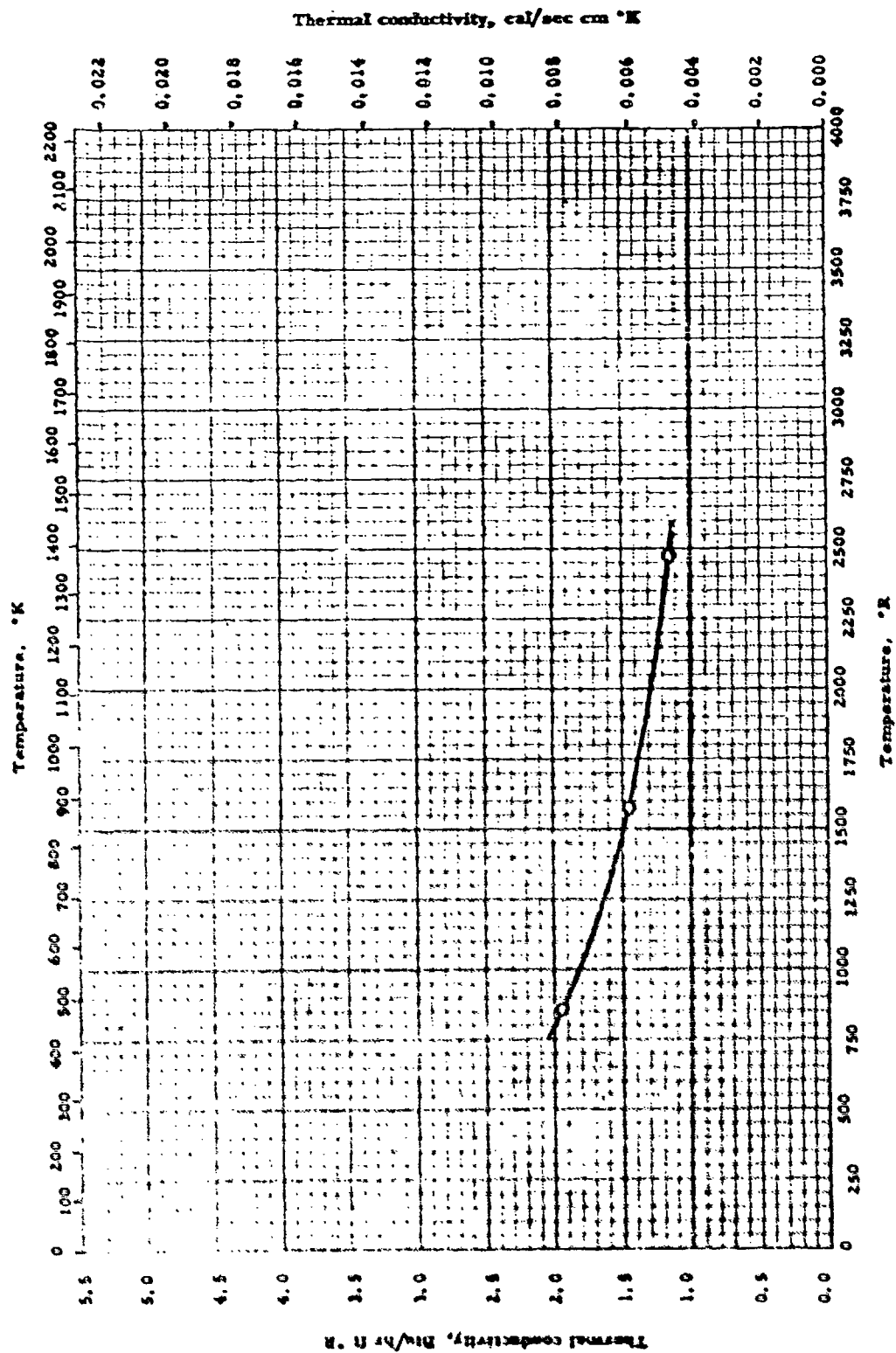


SPECIFIC HEAT -- NICKEL OXIDE (NiO)

SPECIFIC HEAT -- NICKEL OXIDE (NiO)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
0	King, E. G.	57-41	98-533	99.96% NiO; 0.05% CoO; 0.02% acid insoluble; 0.01% Na ₂ O	Guarded sample	Prepared from reagent grade hexahydrates of nickelous nitrate and nickelous sulfate
□	Seltn, H., Dewitt, B. J., and McDonald, H. J.	60-9	123-554	<0.2% impurities	Guarded sample	Transparent cubic crystals
Δ	Terminson, J. R., Demasch, L. et al.	55-38	648-1994	78.51 - 78.54% Ni; 0.01 - 0.1% Si	Drop method; ice calorimeter	Prepared by decomposing Ni(NO ₃) ₂ · 6H ₂ O and heating 8 hr. at 1000°C

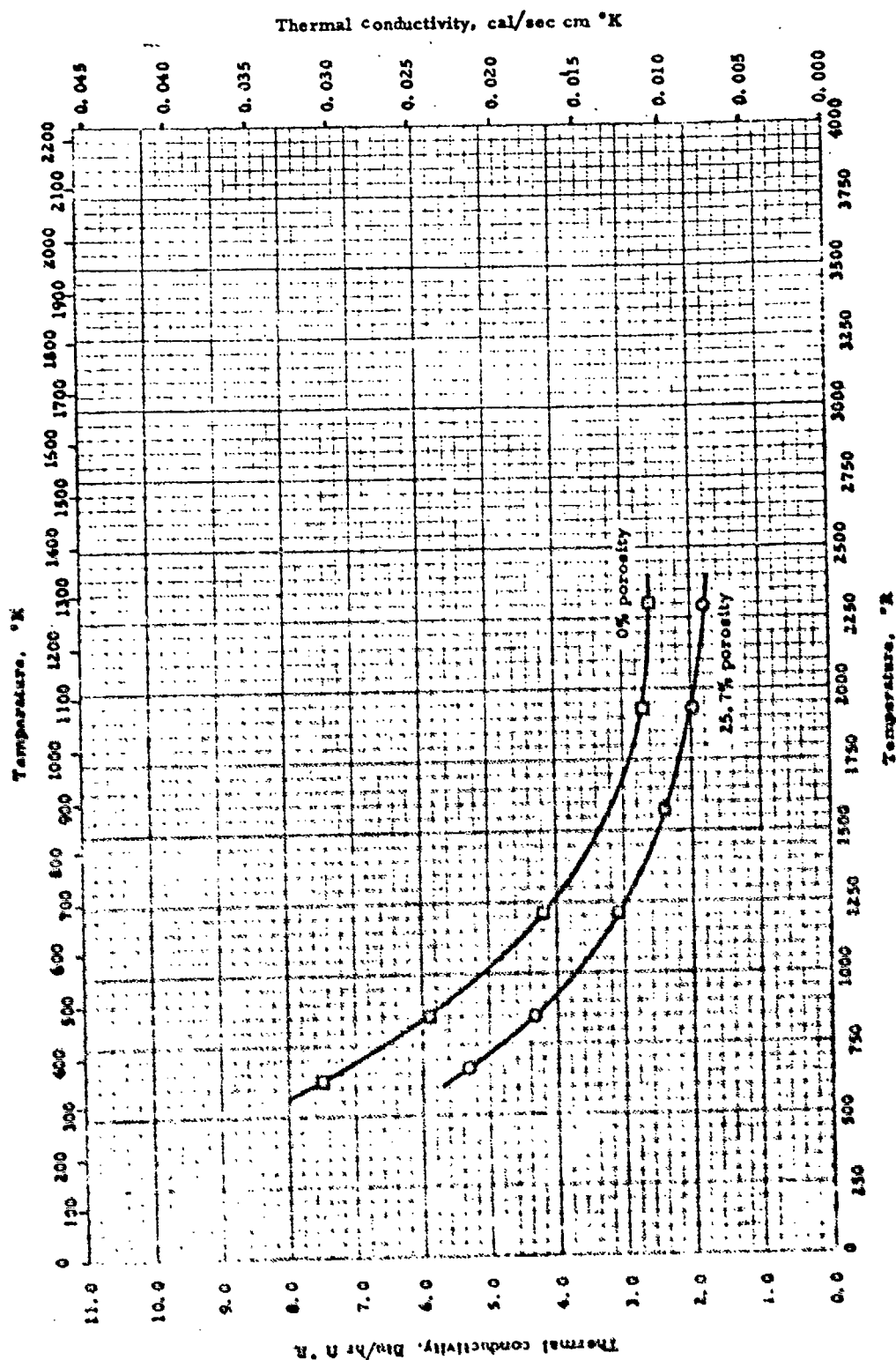


Thermal conductivity -- NICKEL OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- NICKEL OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	Norton, F. H., Kingery, W. D. et al.	54-144	850-2450	50% NiO : 50% MgO	Ellipsoidal envelope	Data were corrected by auth. to zero porosity



Thermal conductivity - NICKEL OXIDE

THERMAL CONDUCTIVITY -- NICKEL OXIDE

REFERENCE INFORMATION

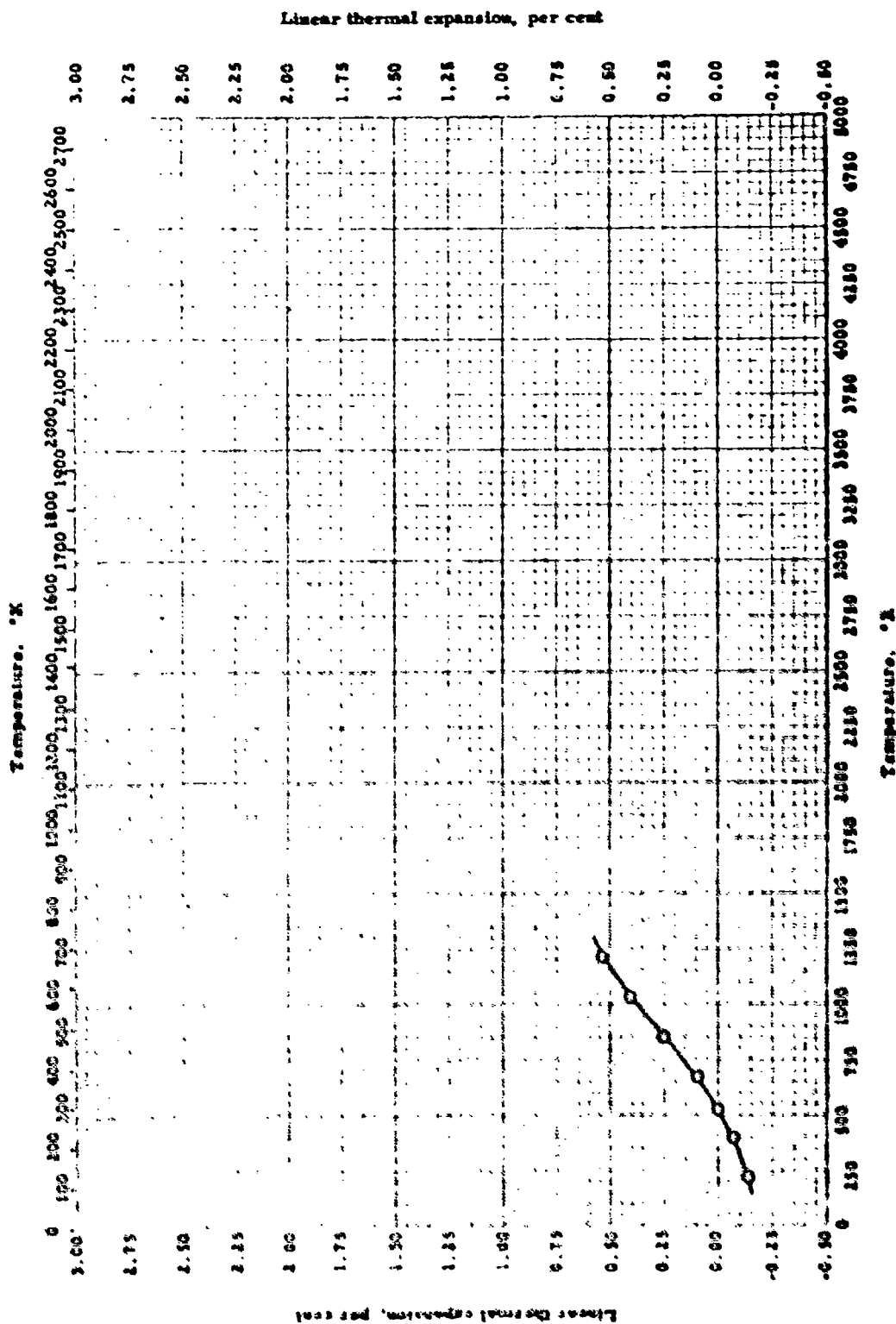
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kingery, W.D. and Franci, J.	54-1	572-2292	$\rho = 315 \text{ lb}_m/\text{ft}^3$; porosity = 25.7%	Comparative, rods	Prepared by calcining c.p. NiO at 1000°C, pressing, and firing at 1500°C in oxidizing atmos. Data were corrected by author to zero porosity
□	Morton, F.H. Kingery, W.D. et al.	54-144	436-2300	NiO	Ellipsoidal envelope	

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LINEAR THERMAL EXPANSION -- NICKEL OXIDE

LINEAR THERMAL EXPANSION -- NICKEL OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Foss, M.	48-5	122-1212	99.0	Dilatometer	N ₂ atmos.

Symbol	Nominal Composition, %					Melting Point	
	Nb ₂ O ₅	Al ₂ O ₃	BeO	MgO	TiO ₂	°R	°K
○	88.78	11.22				3093	1718
	84.07	15.93				3111	1728
	72.59	27.48				3192	1773
	56.88	43.12				3165	1758
□	97.52		2.48			2958	1643
	96.72		3.28			2958	1643
	95.16		4.84			3084	1713
	90.77		9.23			3093	1718
.	83.01		16.89			3084	1713
	75.63		23.27			3102	1723
	71.09		28.91			3102	1723
△	96.35			3.65		3075	1708
	95.19			4.81		3057	1698
	92.95			7.05		3075	1708
	86.83			13.17		3165	1758
	69.66			30.34		3237	1798
	68.73			31.27		3273	1818
	62.24			37.76		3282	1823
◇	89.27				10.73	3165	1758
	86.19				13.81	3138	1743
	80.62				19.38	3093	1718
	67.53				32.47	3147	1748
▽	50.98				49.02	3183	1768
	83.22					3075	1708
	78.81				16.78	3075	1708
	71.26				21.19	3030	1683
	55.35				28.74	3111	1728
					44.65		

MELTING POINT -- NIOBIUM OXIDE + OTHER OXIDES

MELTING POINT -- NIOBIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
52-31	Durbia, E. A. and Harman, C. G.	52-31	3093-3210	Nb ₂ O ₅ + Al ₂ O ₃ system	MP; observed fusion temp. during distilling	Prepared from 99.9% pure Nb ₂ O ₅ and 99.5% pure Al ₂ O ₃
52-31	Idid.	52-31	2958-3102	Nb ₂ O ₅ + BeO system	MP; same as above	Prepared from 99.9% pure Nb ₂ O ₅ and 99.5% pure BeO
52-31	Idid.	52-31	3057-3262	Nb ₂ O ₅ + MgO system	MP; same as above	Prepared from 99.9% pure Nb ₂ O ₅ and 99.5% pure MgO
52-31	Idid.	52-31	3093-3183	Nb ₂ O ₅ + TiO system	MP; same as above	Prepared from 99.9% pure Nb ₂ O ₅ and 99.5% pure TiO
52-31	Idid.	52-31	3020-3228	Nb ₂ O ₅ + ZrO ₂ system	MP; same as above	Prepared from 99.9% pure Nb ₂ O ₅ and 99.5% pure ZrO ₂

PROPERTIES OF NIOBIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	279 lb _m /ft ³ *	4.47 g/cm ³ *
Melting Point	3210°R	1785°K
Heat of Fusion	167 Btu/lb _m	93 cal/g
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook Chemistry and Physics (Ref. 59-2)

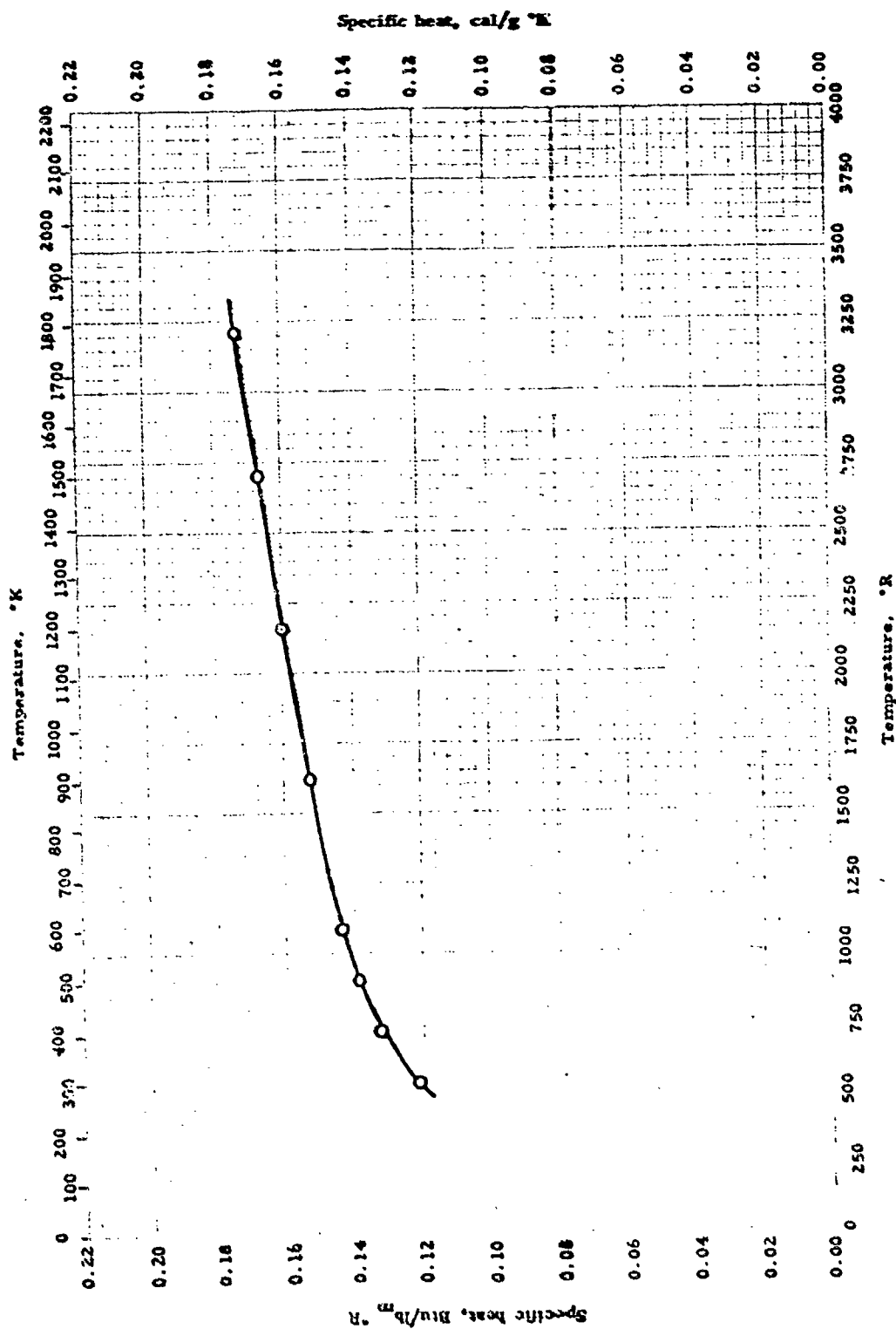
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
	○ 3084	1713
	□ 3213 ± 9	1785 ± 5
	Δ 3167	1759
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
	□ 166.5	92.5
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF NIOBIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E.A. and Harman, C.G.	52-31	3084	99.9% Nb ₂ O ₅	MP: meas. approx. fu- sion temp. during sin- tering	
□	Orr, R.L.	53-57	3213	Nb ₂ O ₅ ; 0.03% Si; <0.05% Mg <0.01% Ti	MP: visual observation; calibrated Pt-Rh thermocouple ΔH: from enthalpy data above and below MP by drop method into copper block calorimeter	Heated to 1050°C before testing. Premelting ob- served 1750-1785°K
Δ	Reisman, A. and Holtzberg, F.	52-146	3167	Nb ₂ O ₅	MP: thermal analysis	Melts congruently



SPECIFIC HEAT -- NIOBIUM OXIDE (Nb₂O₅)

SPECIFIC HEAT -- NIOBIUM OXIDE (Nb_2O_5)

REFERENCE INFORMATION

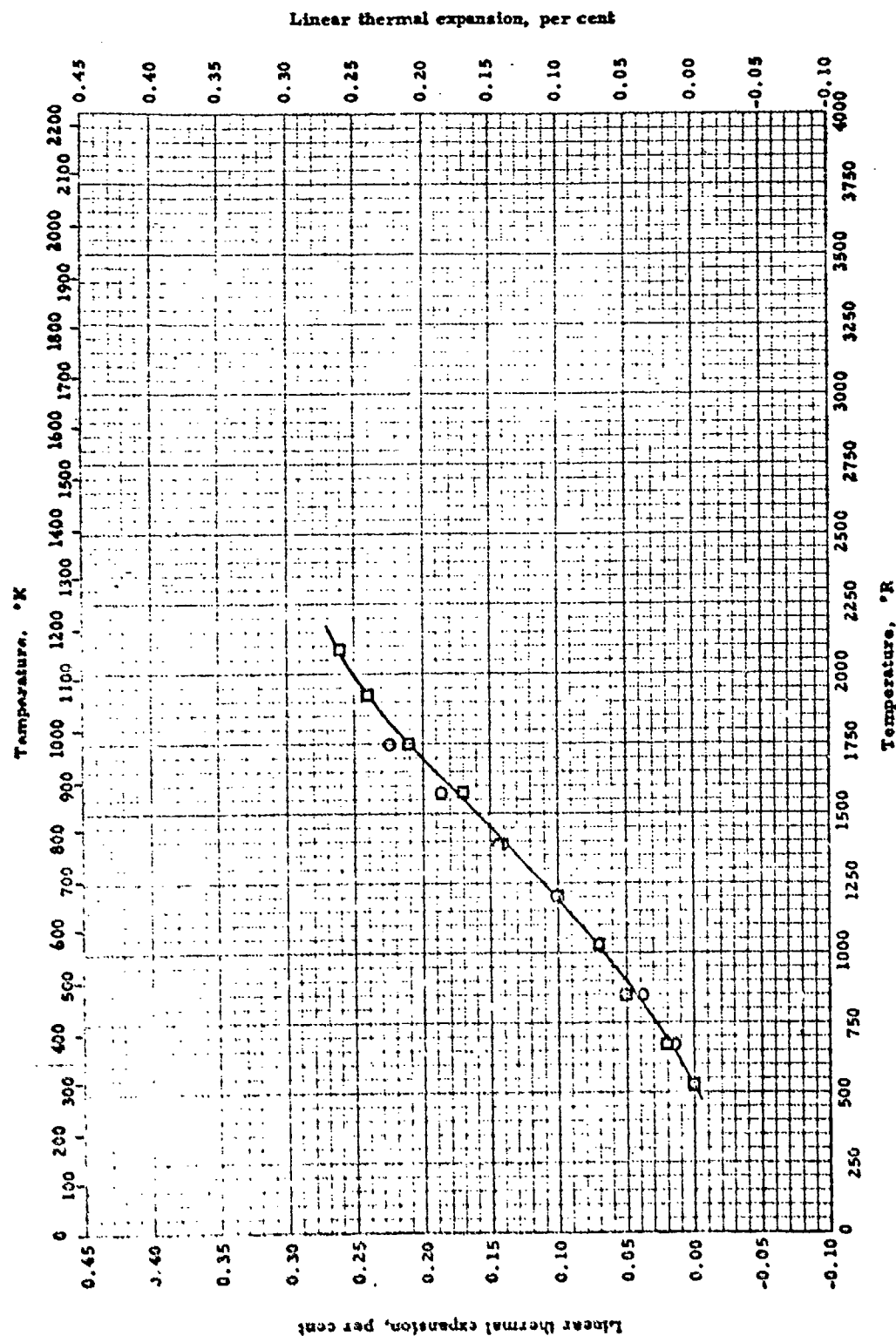
Sym bol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Orr, R. L.	53-57	686-3257	<0.05% Mg; 0.03% Si; <0.01% Ti	Drop method; copper block calorimeter	Heated to 1050°C before testing

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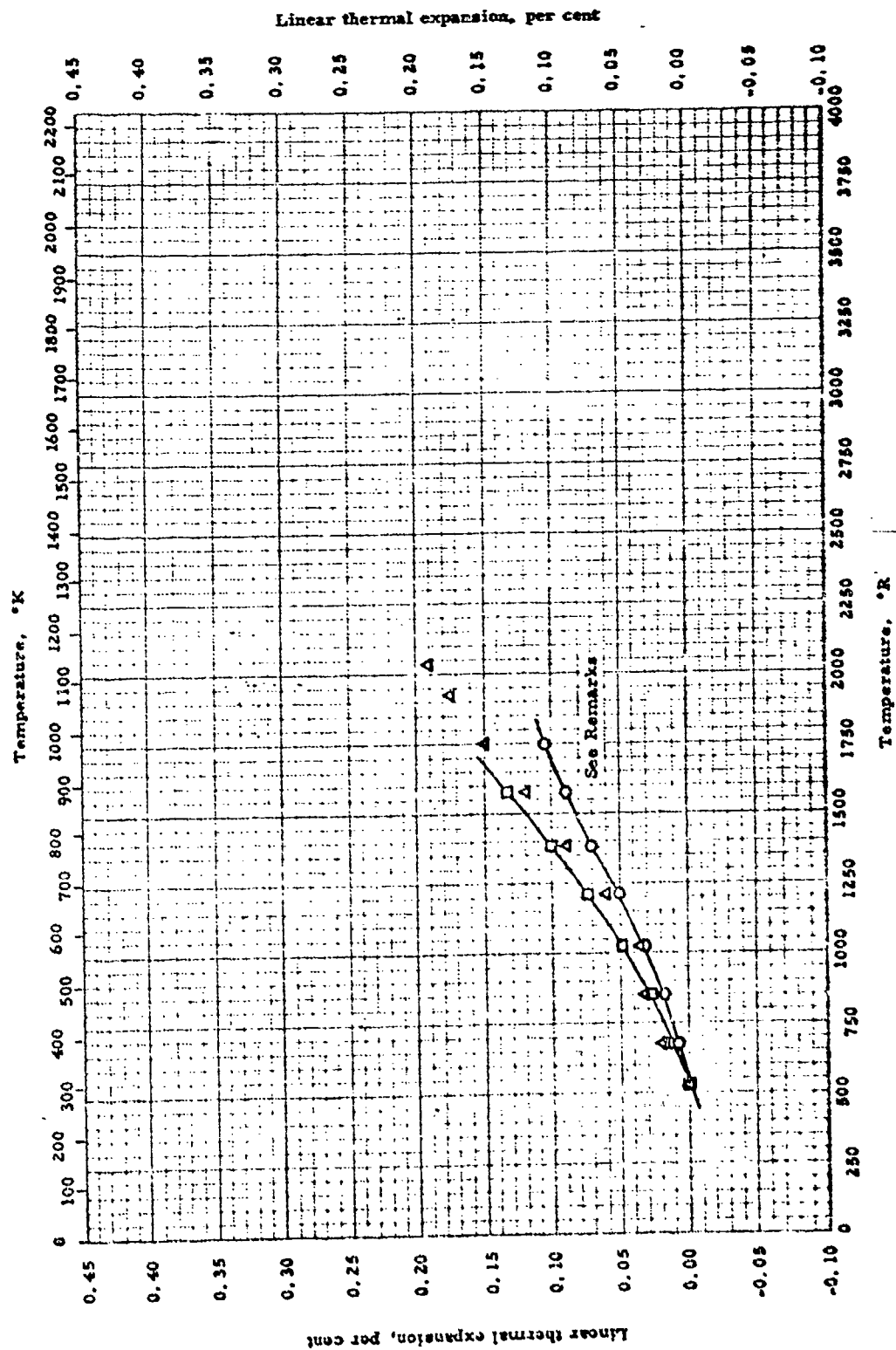


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE - ALUMINUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE - ALUMINUM OXIDE

REFERENCE INFORMATION

Sym Bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A., Wagner, H. E., and Harman, C. G.	52-34	528-1752	~72.3% Nb ₂ O ₅ ; 27.7% Al ₂ O ₃ ; pre- pared from c.p. raw materials (ma- jor impurity: Ta ₂ O ₅)	Interferometer	Calcined 2 hr. at 1200°C; fired at 1480°C (Al ₂ O ₃ · Nb ₂ O ₅)
□	Durbin, E. A. and Harman, C. G.	52-31	528-2094	72.3% Nb ₂ O ₅ ; 27.7% Al ₂ O ₃	Interferometer	Fired 2 hr. at 1450°C; cooled in 24 hr. (Al ₂ O ₃ · Nb ₂ O ₅)

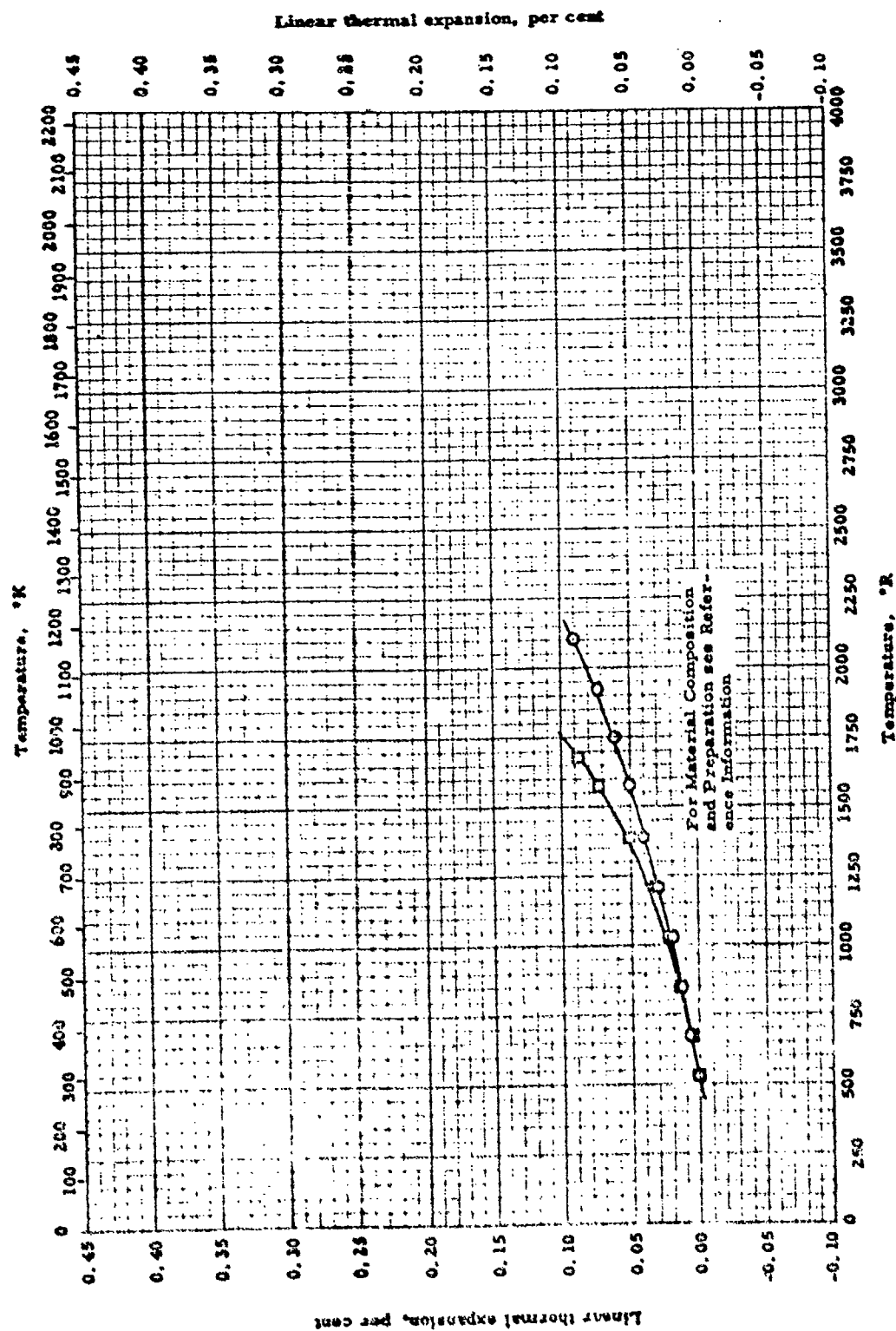


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A., Wagner, H. E., and Harman, C. G.	52-34	528-1752	76.9% NbO ₂ ; 23.1% TiO ₂ ; c.p. raw materials (Ta ₂ O ₅ major impurity)	Interferometer	Calcined 2 hr. at 1120°C; fired at 1400°C (TiO ₂ · Nb ₂ O ₅)
□	Ibid.	52-34	528-1752	62.5% NbO ₂ ; 37.5% TiO ₂ ; raw ma- terial, same as above	Same as above	Same as above (TiO ₂ · Nb ₂ O ₅ + TiO ₂)
Δ	Durbin, E. A. and Harman, C. G.	52-31	528-2040	76.9% NbO ₂ ; 23.1% TiO ₂	Same as above	Fired 2 hr. at 1450°C; cooled in 24 hr. (TiO ₂ · Nb ₂ O ₅)

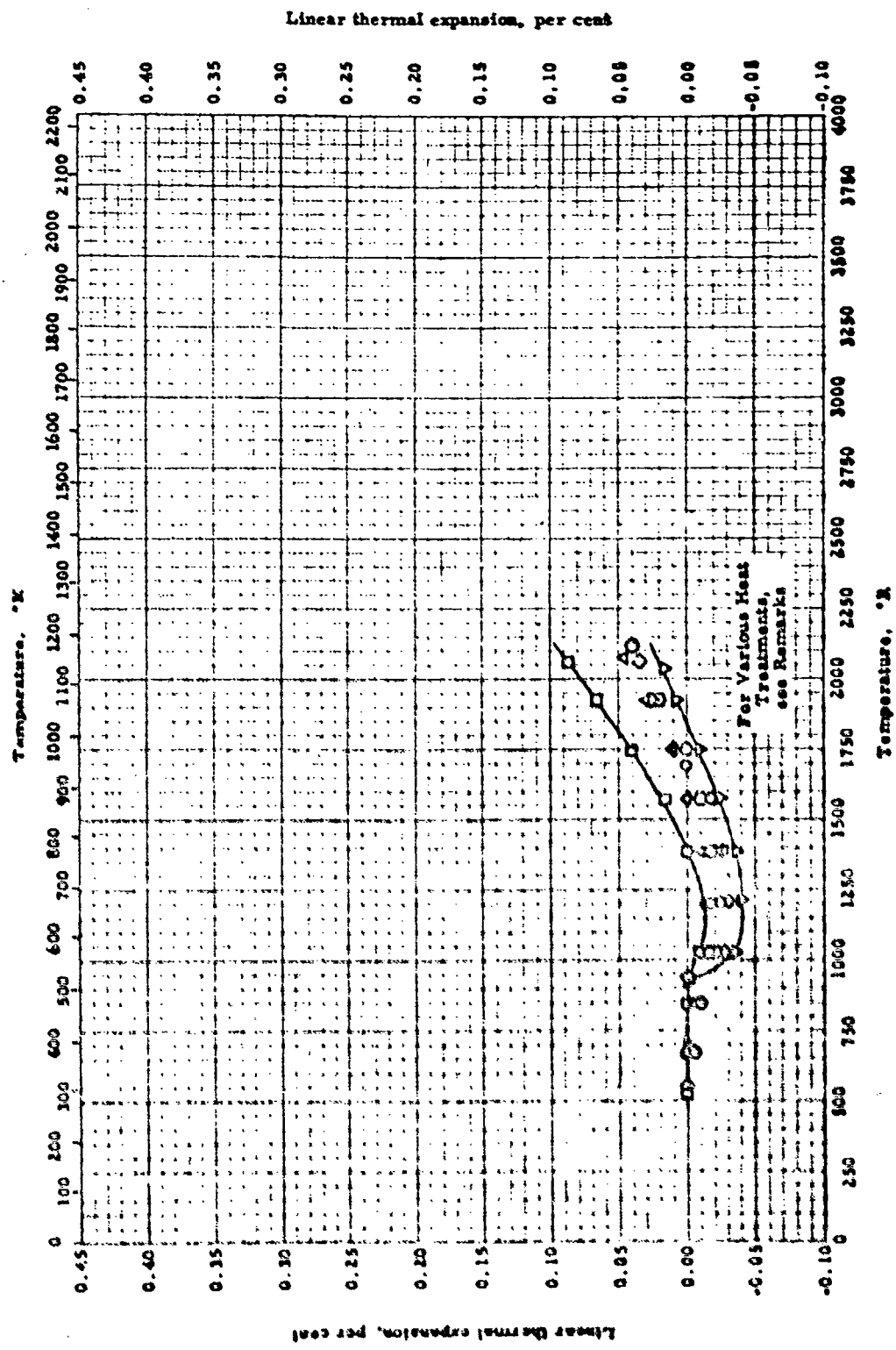


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + ZIRCONIUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + ZIRCONIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Durbin, E. A. and Herman, C. G.	52-31	528-2112	~86.6% Nb ₂ O ₅ ; 13.4% ZrO ₂	Interferometer	Fired 2 hr. at 1400°C; cooled in 24 hr. (3Nb ₂ O ₅ + ZrO ₂)
□	Durbin, E. A., Wagner, H. E. and Herman, C. G.	52-34	528-1680	~86.6% Nb ₂ O ₅ ; 13.4% ZrO ₂ ; pre- pared from c.p. raw materials; (major impurity: Ta ₂ O ₅) Apparent porosity = 15%	Interferometer	Calcined 2 hr. at 1065°C; fired at 1345°C (3Nb ₂ O ₅ + ZrO ₂) (a form of stabilized zirconia)



LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE

REFERENCE INFORMATION

Sym Des	Investigator	Ref.	Temp., °C	Material Composition	Test Method	Remarks
○	Darkin, E. A., and Wagner, H. E., and Karmann, C. G.	52-34	528-1752	99.65 Nb ₂ O ₅ ; remainder mostly Ti ₂ O ₅	Interferometer	Fired at 1455°C. Crystals medium coarse to coarse
□	Darkin, E. A., and Karmann, C. G.	52-31	528-2058	Not given	Interferometer	Heated 2 hr. at 1318°C, furnace cooled
△	ibid.	52-31	528-2058	Same as above	Same as above	Heated 2 hr. at 1370°C, furnace cooled
○	ibid.	52-31	528-2058	Same as above	Same as above	Heated 2 hr. at 1318°C, air quenched
▽	ibid.	52-31	528-2040	Same as above	Same as above	Heated 2 hr. at 1370°C, air quenched
○	ibid.	52-31	528-2112	Same as above	Same as above	Heated 2 hr. at 1370°C, furnace cooled; refired for 100 hr. at 1286°C, furnace cooled

PROPERTIES OF PROTACTINIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	838.4 lb _m /ft ³	13.43 g/cm ³
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
O	838.4	13.43

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF PROTACTINIUM OXIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, R	Material Composition	Test Method	Remarks
O	Zachariasen, W. H.	51-53	Room	PaO	p: computed from x-ray measurements of lattice	

PROPERTIES OF STRONTIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	293 lb _m /ft ³ *	4.7 g/cm ³ *
Melting Point	4860°R	2760°K
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .	2189 ₀ ⁰ Btu/lb _m	1216 ₀ ⁰ cal/g

* Handbook of Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
O 4865 2763

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g
O 2189₀⁰ ± 14 1216₀⁰ ± 5

PROPERTIES OF STRONTIUM OXIDE

REFERENCE INFORMATION

Sym Sol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Tremble, F.	49-16	4866	SrO	MP; not given	
□	Moore, G. E., Allison, H. W., and Strathairn, J. D.	50-24	0	SrO	Δh: from vapor pressure by weight loss of wire inside bulb using radioactive counting; disappearing filament optical pyrometer	

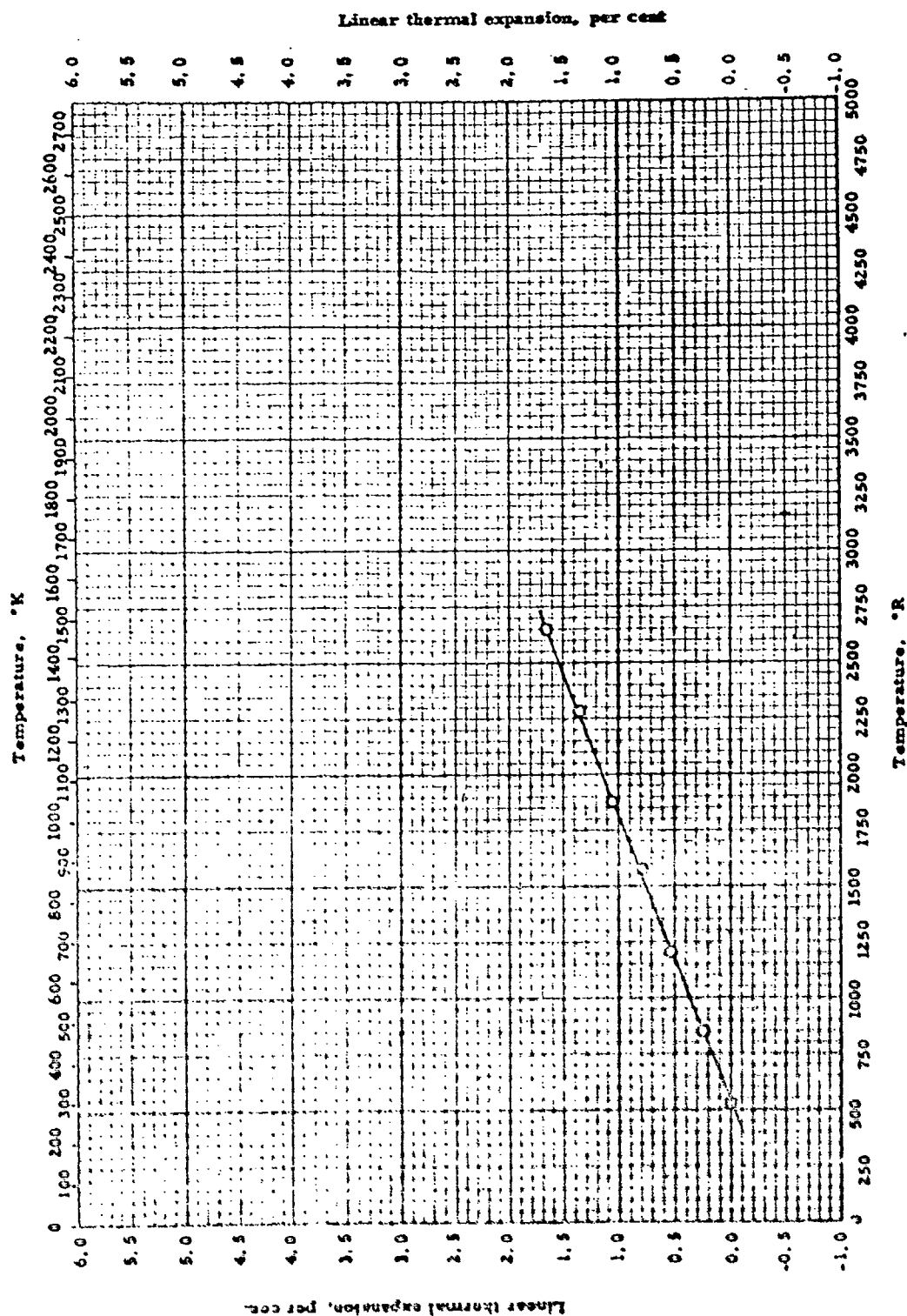
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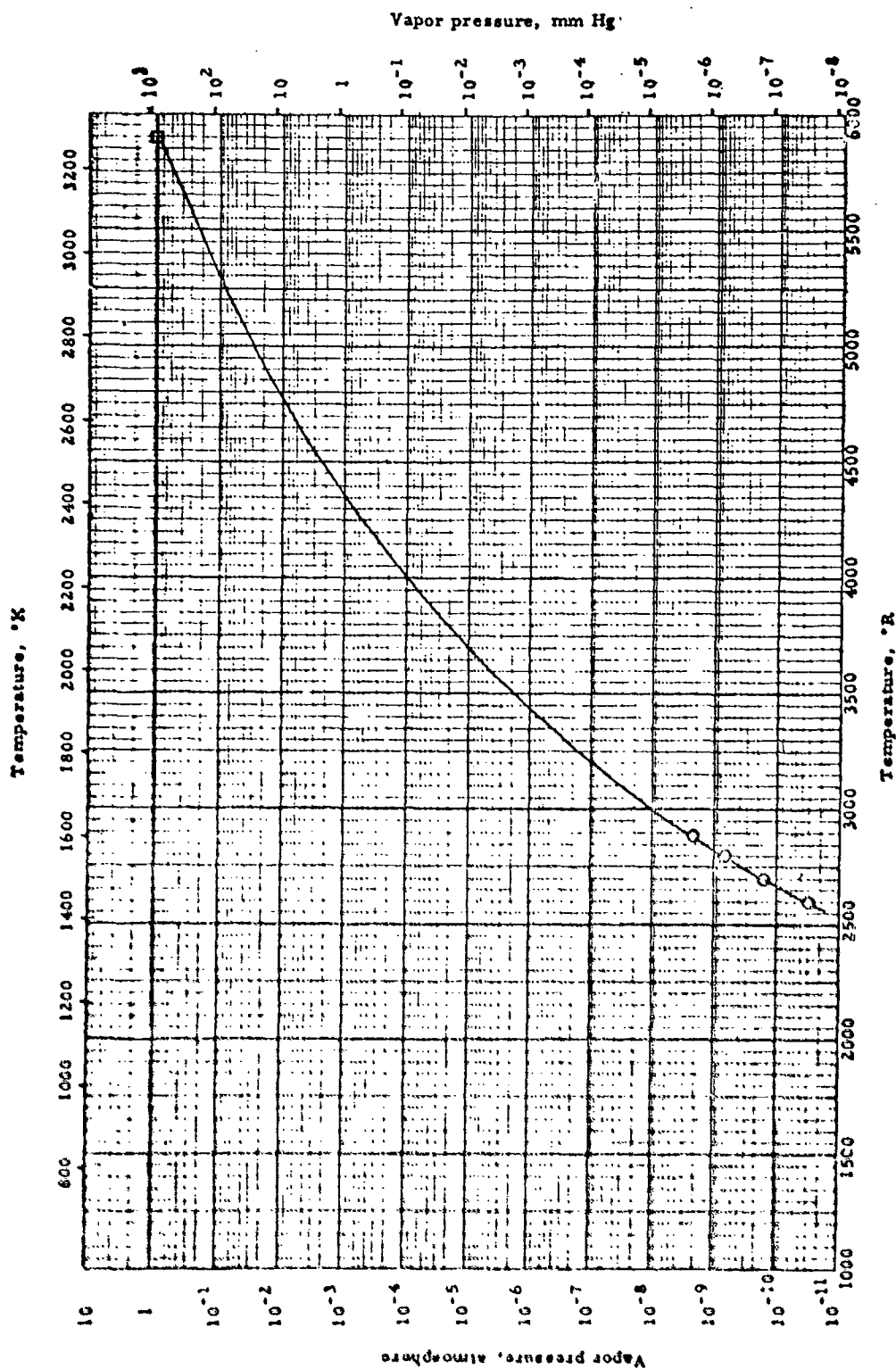


LINEAR THERMAL EXPANSION -- STRONTIUM OXIDE

LINEAR THERMAL EXPANSION -- STRONTIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beals, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade SrO	X-ray back reflection	

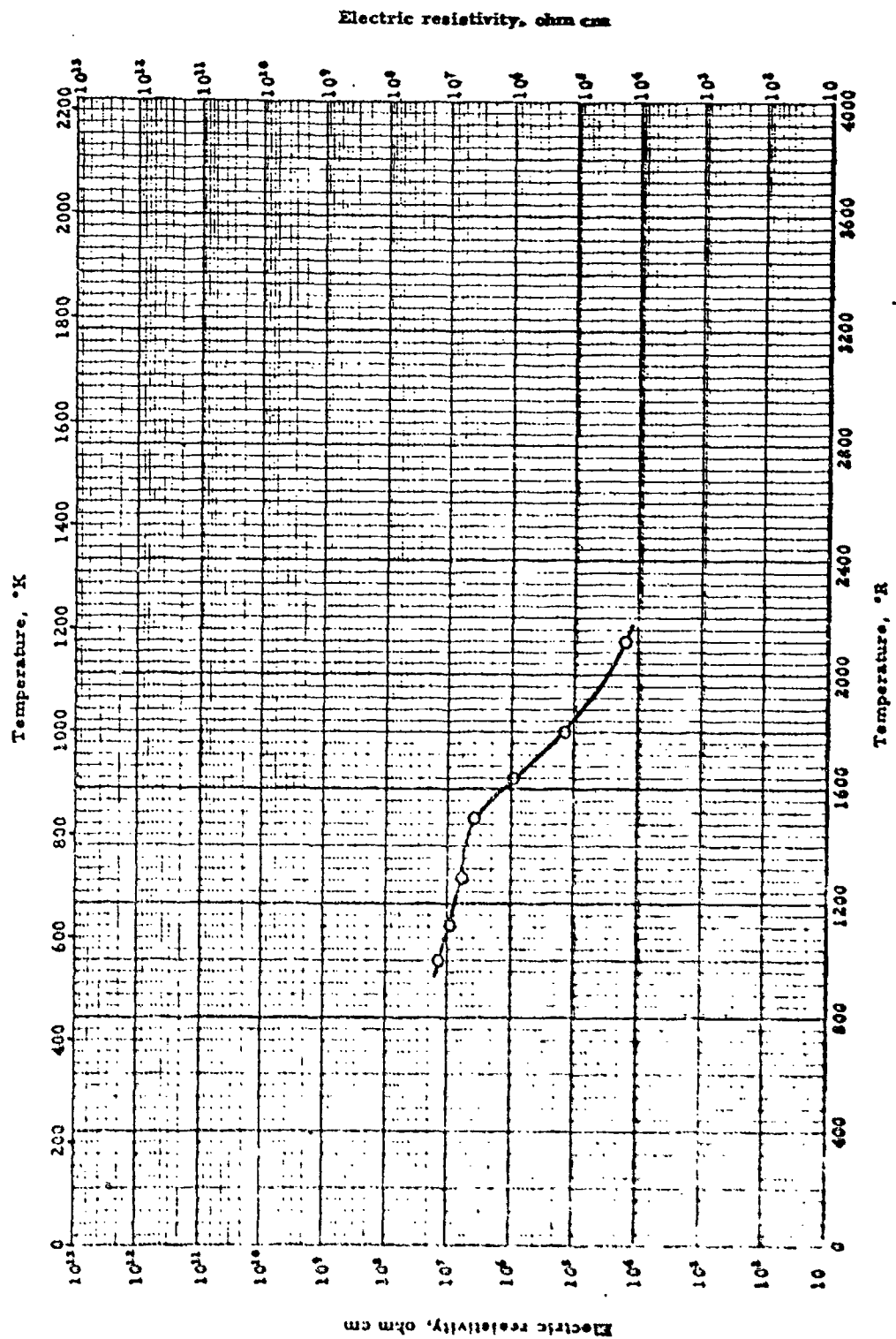


VAPOR PRESSURE -- STRONTIUM OXIDE

VAPOR PRESSURE -- STRONTIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, C. E., Allison, H. W. and Struthers, J. D.	50-24	1260-2880	Not given	Langmuir weight loss method	Pt filament with SrO coat- ing. Auth. est. accuracy +1%
□	Trombe, F.	49-16	589	Not given	Not given	

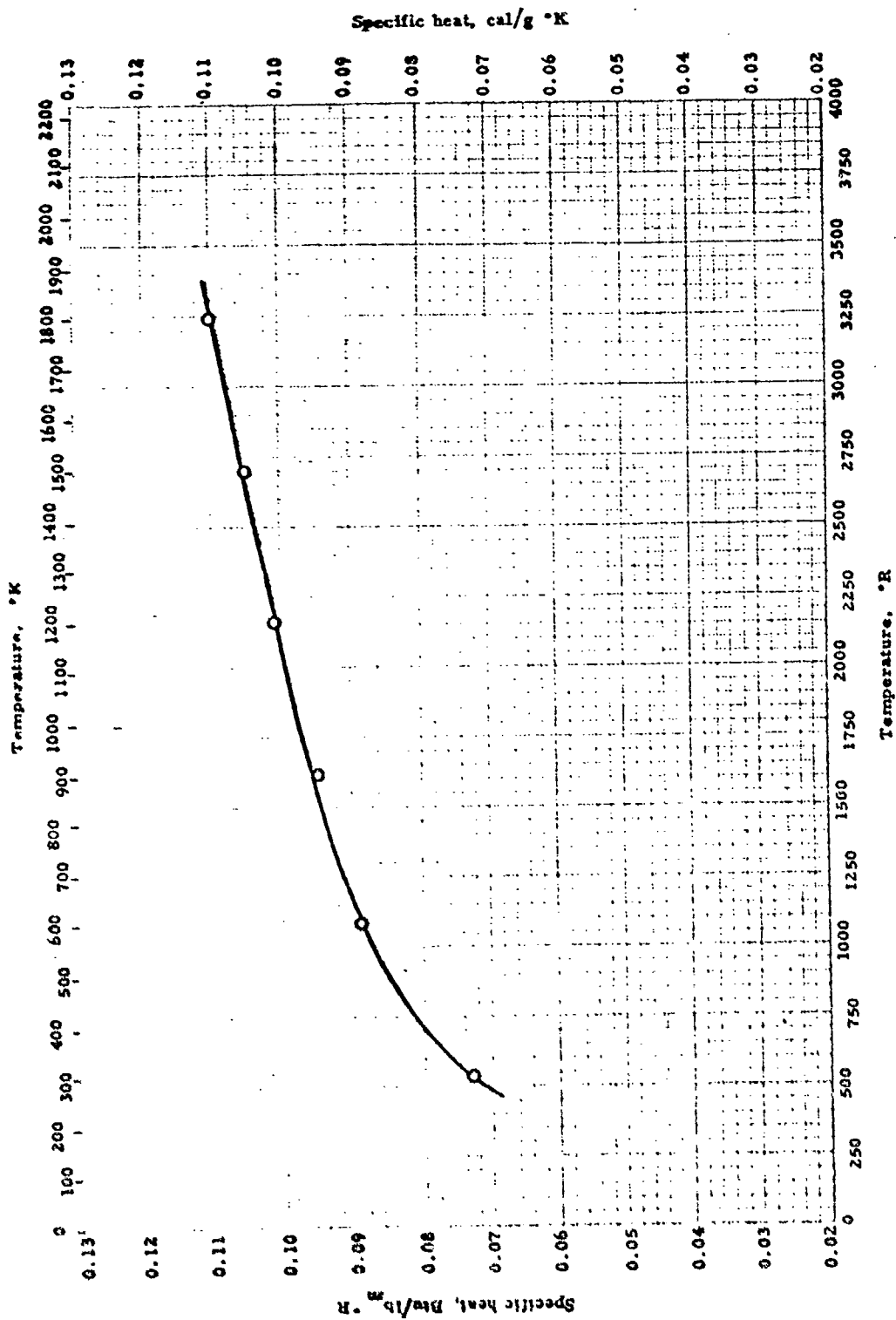


ELECTRIC RESISTIVITY -- STRONTIUM OXIDE

ELECTRIC RESISTIVITY -- STRONTIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nakhodchova, A. P.	56-73	1000-2120	SrO	Potential drop; sample temp. by Mo-Ni thermocouple. In range 800-900°C, optical pyrometer was also used.	Formed from chemically pure materials. Baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace. Meas. under 10 ⁻⁵ mm Hg vac., const. current.

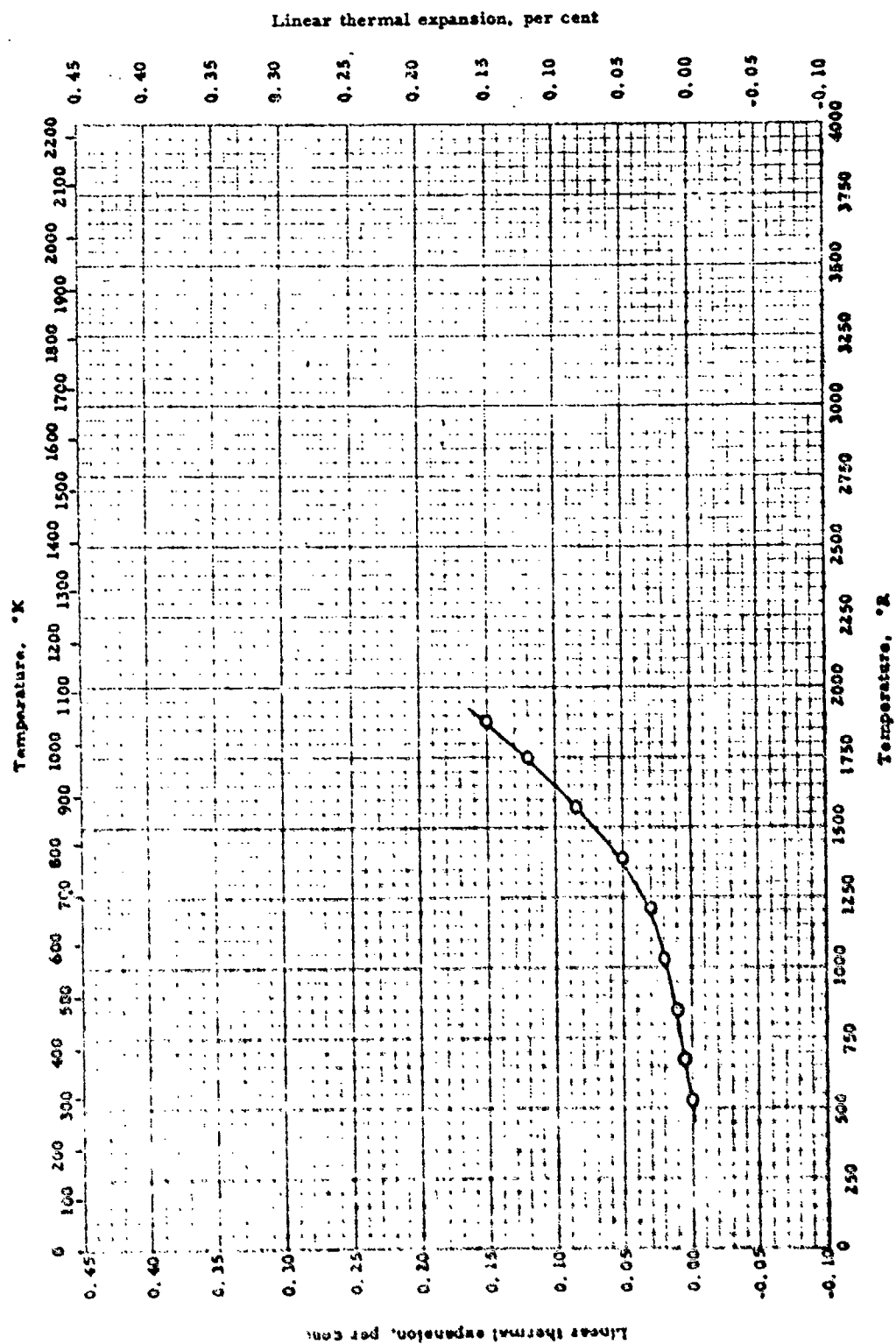


SPECIFIC HEAT -- TANTALUM OXIDE

SPECIFIC HEAT -- TANTALUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ort, R. L.	53-57	712-3245	Virtually atomic wt. purity Ta ₂ O ₅	Drop method; copper block calorimeter	Heated to 1200°C before testing



LINEAR THERMAL EXPANSION -- TANTALUM OXIDE

LINEAR THERMAL EXPANSION -- TANTALUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Darwin, E. A. and Hartman, C. O.	52-31	522-1932	Ta ₂ O ₅	Interferometer	Fired to 1425°C and furnace cooled

PROPERTIES OF TELLURIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	356 lb _m /ft ³ *	5.7 g/cm ³ *
Melting Point	1813°R **	1006°K **
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation	649 _{1630°R} Btu/lb _m	360 _{905°K} cal/g

* Handbook of Chem. and Phys. (Ref. 57-60)

** Data on Chemicals (Ref. 49-55)

REPORTED VALUES

Density:

lb_m/ft³

g/cm³

Melting Point:

°R

°K

Heat of Fusion:

Btu/lb_m

cal/g

Heat of
Vaporization:

Btu/lb_m

cal/g

Heat of
Sublimation:

Btu/lb_m

cal/g

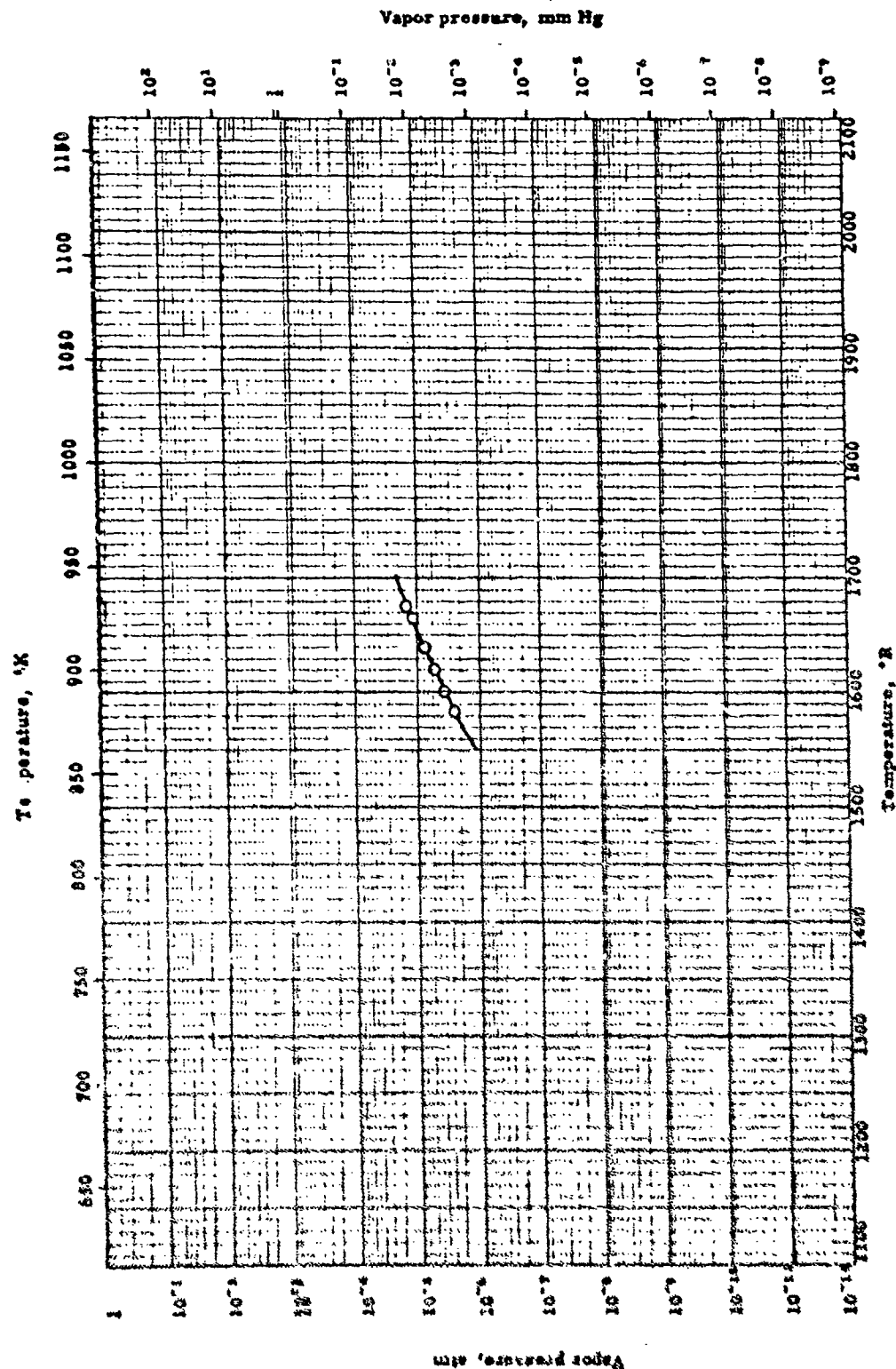
Q 549_{1629°R}

360_{905°K}

PROPERTIES OF TELLURIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Cyena, E.	41-5	1629	TeO ₂	Ah, 1 from vapor pressure measured by Knudsen effusion cell	

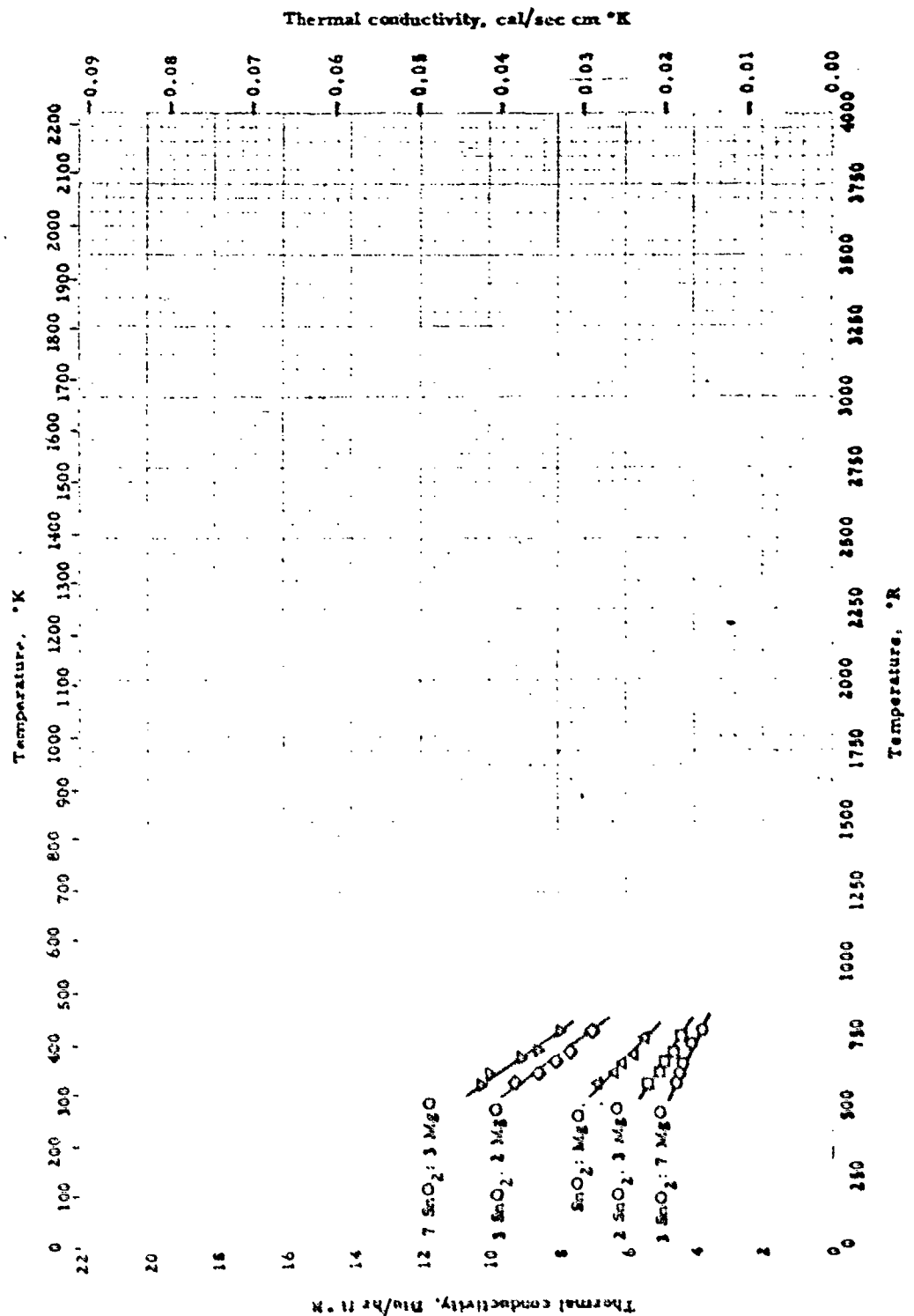


VAPOR PRESSURE -- TELLURIUM OXIDE

VAPOR PRESSURE -- TELLURIUM OXIDE

REFERENCE INFORMATION

Sum No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Uyeno, M.	41-5	1583-1675	TeO ₂	Not described here, refers to others	



Thermal conductivity -- TIN OXIDE - MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- TIN OXIDE + MAGNESIUM OXIDE

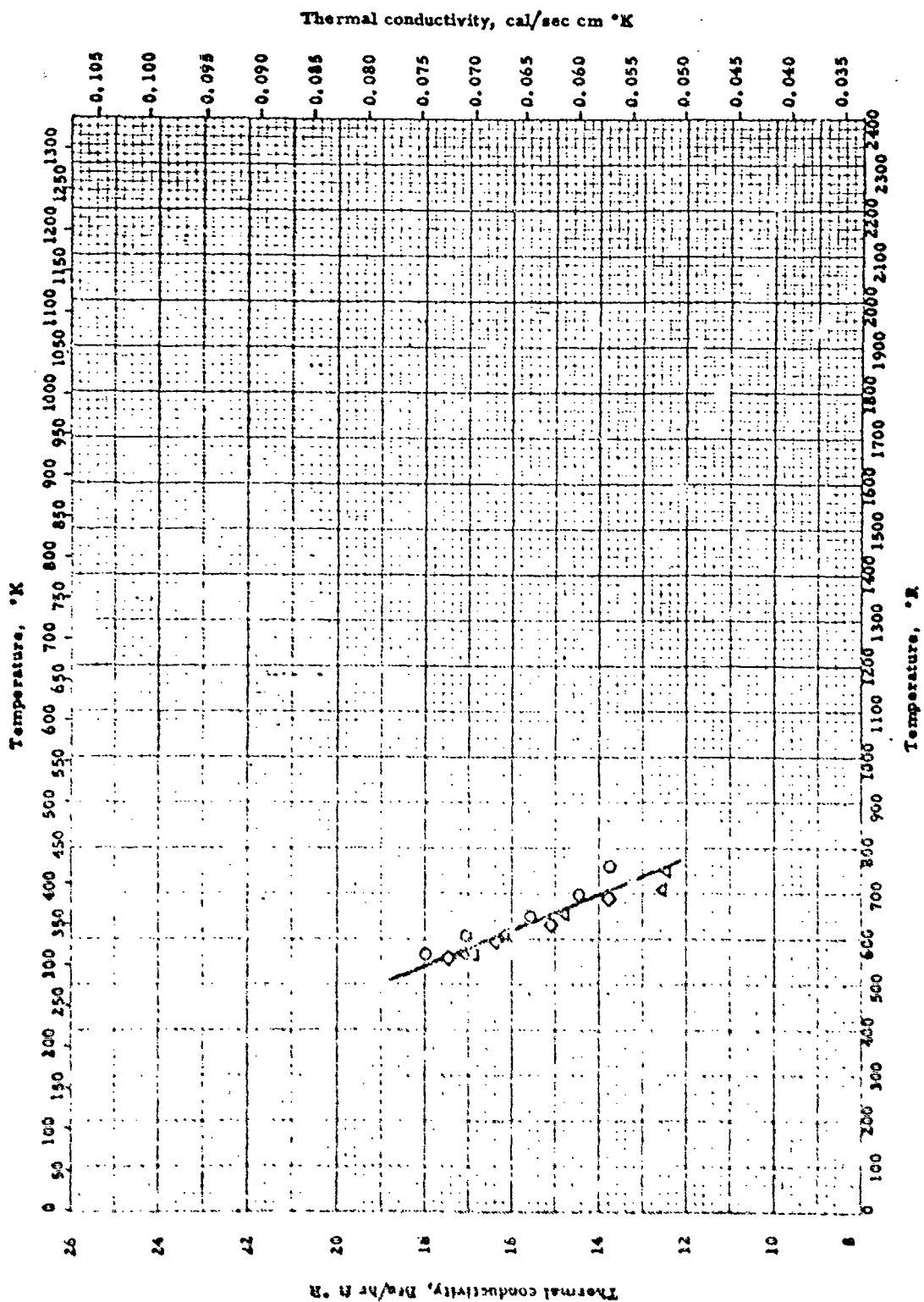
REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-4	573-759	3SnO ₂ : 7MgO; 61.6% SnO ₂ ; 38.4% MgO (0.12% water absorption); $\rho = 266 \text{ lb}_m/\text{ft}^3$	Comparative; rods	Fired 1.5 hr. at 2750°F
□	Ibid.	53-4	571-746	2SnO ₂ : 3MgO; 71.4% SnO ₂ ; 28.6% MgO (0.09% water absorption); $\rho = 300 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
△	Ibid.	53-4	574-755	SnO ₂ : MgO; 78.9% SnO ₂ ; 21.1% MgO (0.19% water absorption); $\rho = 324 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
◇	Ibid.	53-4	577-757	3SnO ₂ : 2MgO; 84.9% SnO ₂ ; 15.1% MgO (0.46% water absorption); $\rho = 340 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
▽	Ibid.	53-4	568-754	7SnO ₂ : 3MgO; 89.7% SnO ₂ ; 10.3% MgO (0.70% water absorption); $\rho = 346 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above

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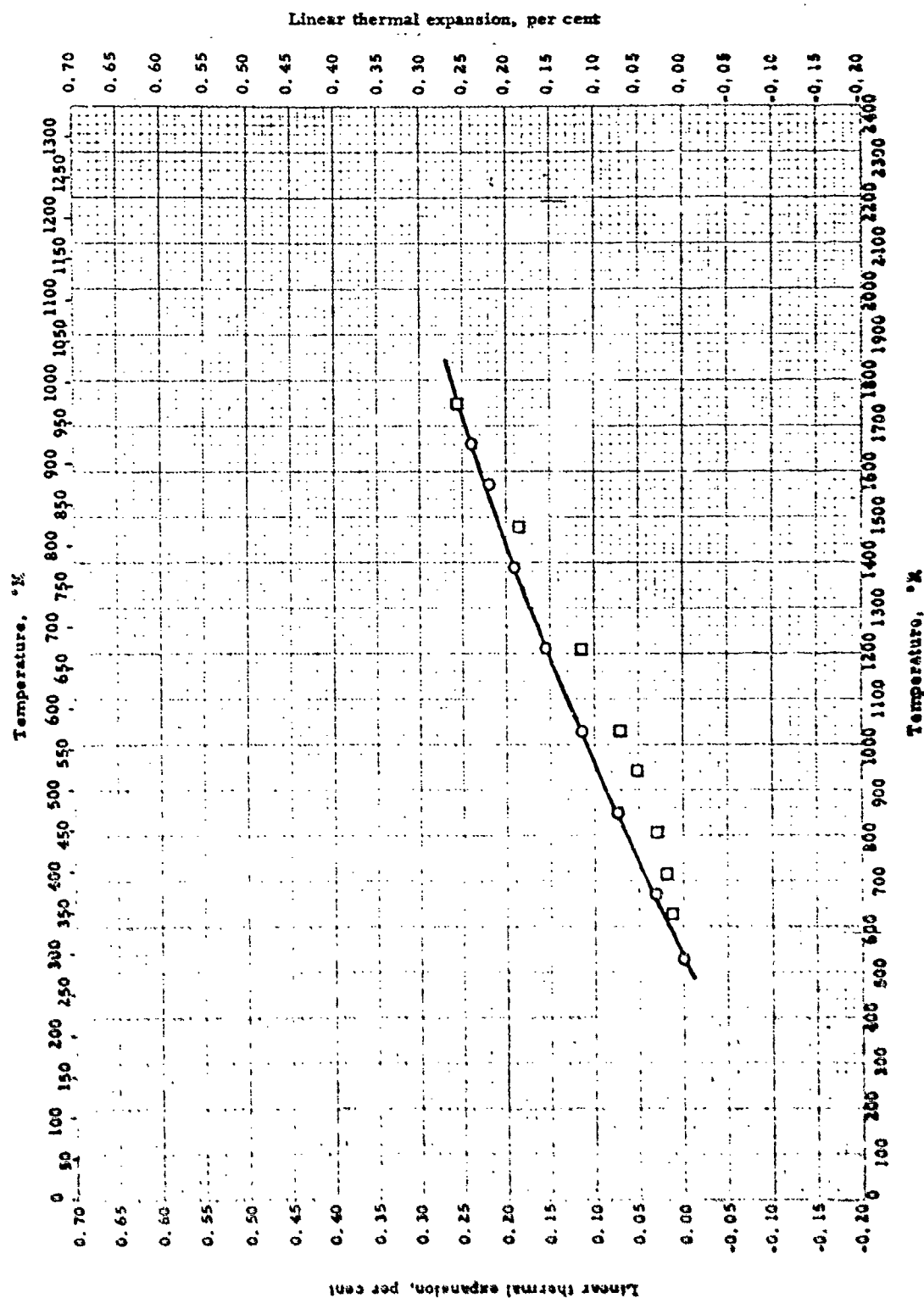


THEMAL CONDUCTIVITY -- TIN OXIDE

THERMAL CONDUCTIVITY -- TIN OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
53-4	New Jersey Ceramic Research Station	53-4	567-762	98% SnO ₂ ; impurities not given; $p = 406 \text{ lb}_m/\text{ft}^3$	Comparative method	Fired 1 hr. at 2600°F; tested in vacuum
54-47	Quirk, J. and Harrison, C. G.	54-47	564	97% SnO ₂ (approx.); 0.1-1.0% Si; 0.9% ZnO; 0.05-0.50% Fe; 0.01-0.10% Ca; others <0.01%; apparent porosity = 2.6%	Comparative, rods	Sintered matrix. Auth. est. accuracy $\pm 5\%$
53-3	New Jersey Ceramic Research Station	53-3	560-760	98% SnO ₂ , $p = 413 \text{ lb}_m/\text{ft}^3$	Comparative, rods (Cu standard)	Furnished by Metal and Thermit Corp.
53-3	Idid.	53-3	560-690	98% SnO ₂ , $p = 410 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above



LINEAR THERMAL EXPANSION -- TIN OXIDE

LINEAR THERMAL EXPANSION -- TIN OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-47	Quirk, J. and Harmon, C. G.	523-1662	97% SnO ₂ ; 0.9% ZnO; 0.1-1.0% Si; 0.05-0.5% Fe; 0.01-0.1% Ca; < 0.01% others; apparent porosity = 0.4%	Interferometer	Sintered matrix
46-13	Hummel, F. A. and Henry, E. C.	528-1752	SnO ₂	Probably quartz tube dilatometer	

PROPERTIES OF VANADIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	359 lb _m /ft ³ *	5.76 g/cm ³ *
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation	3600 Btu/lb _m	2000 cal/g

* Handbook Chemistry and Physics, (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

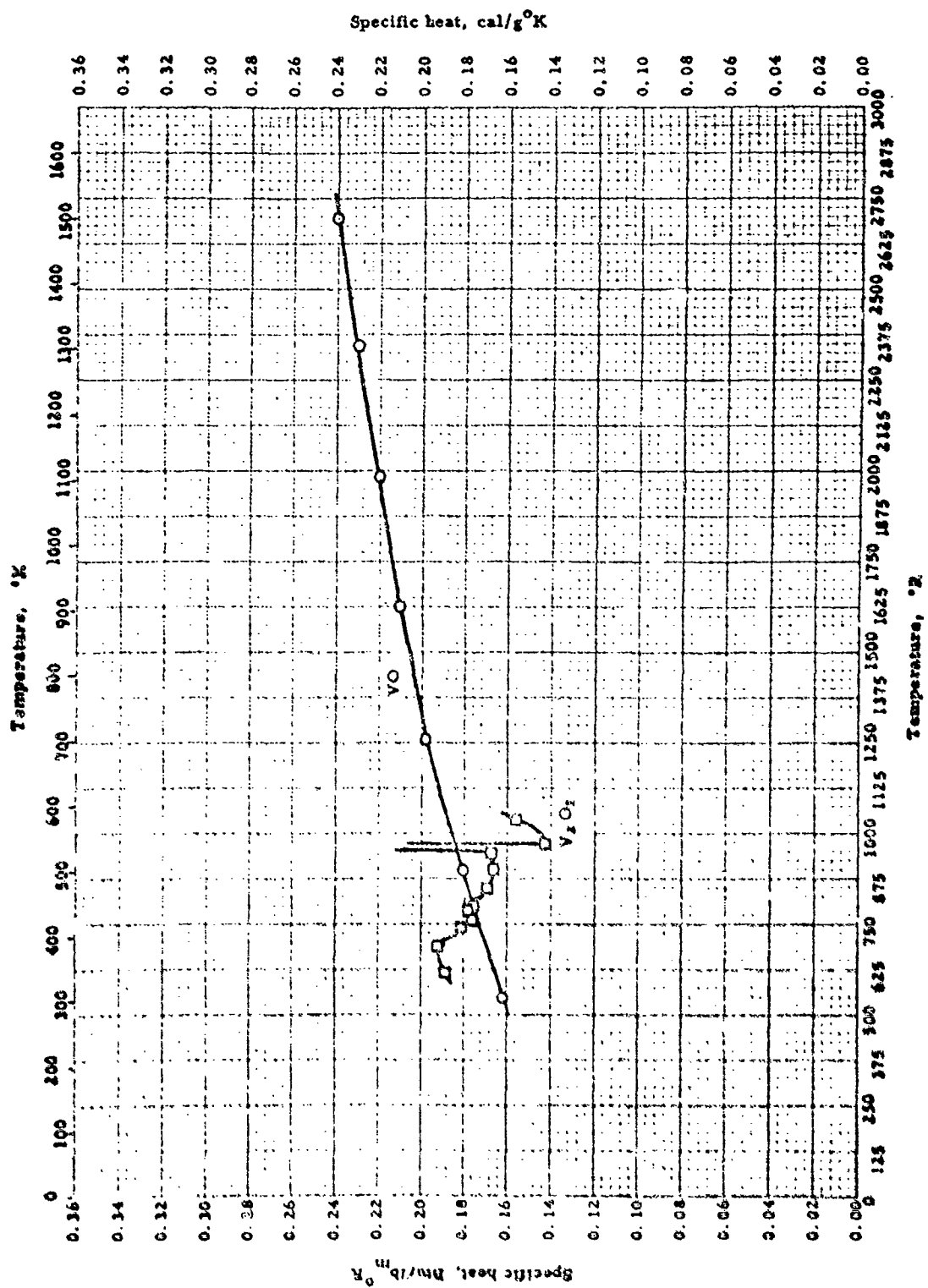
Heat of Sublimation: Btu/lb_m cal/g

O	1636 ⁰ ₀ °R ± 8	2021 ⁰ ₀ °R ± 4
□	3479 ⁰ ₀ °R ± 16	1932 ⁰ ₀ °K ± 9

PROPERTIES OF VANADIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Dehnen, M. G., Estroff, J. and Chapin, W. A.	56-44	0	VO	Δh_v : from vapor pressure measured by Knudsen effusion cell with mass spectrometer; from slope of vapor pressure curve Δh_g : from vapor pressure measured by Knudsen effusion cell with mass spectrometer; from weight loss and estimated entropy	Vapor pressure measured 3024-3510 R Same as above
□	Idid.	56-44	0	VO		



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WADC TR 55-476

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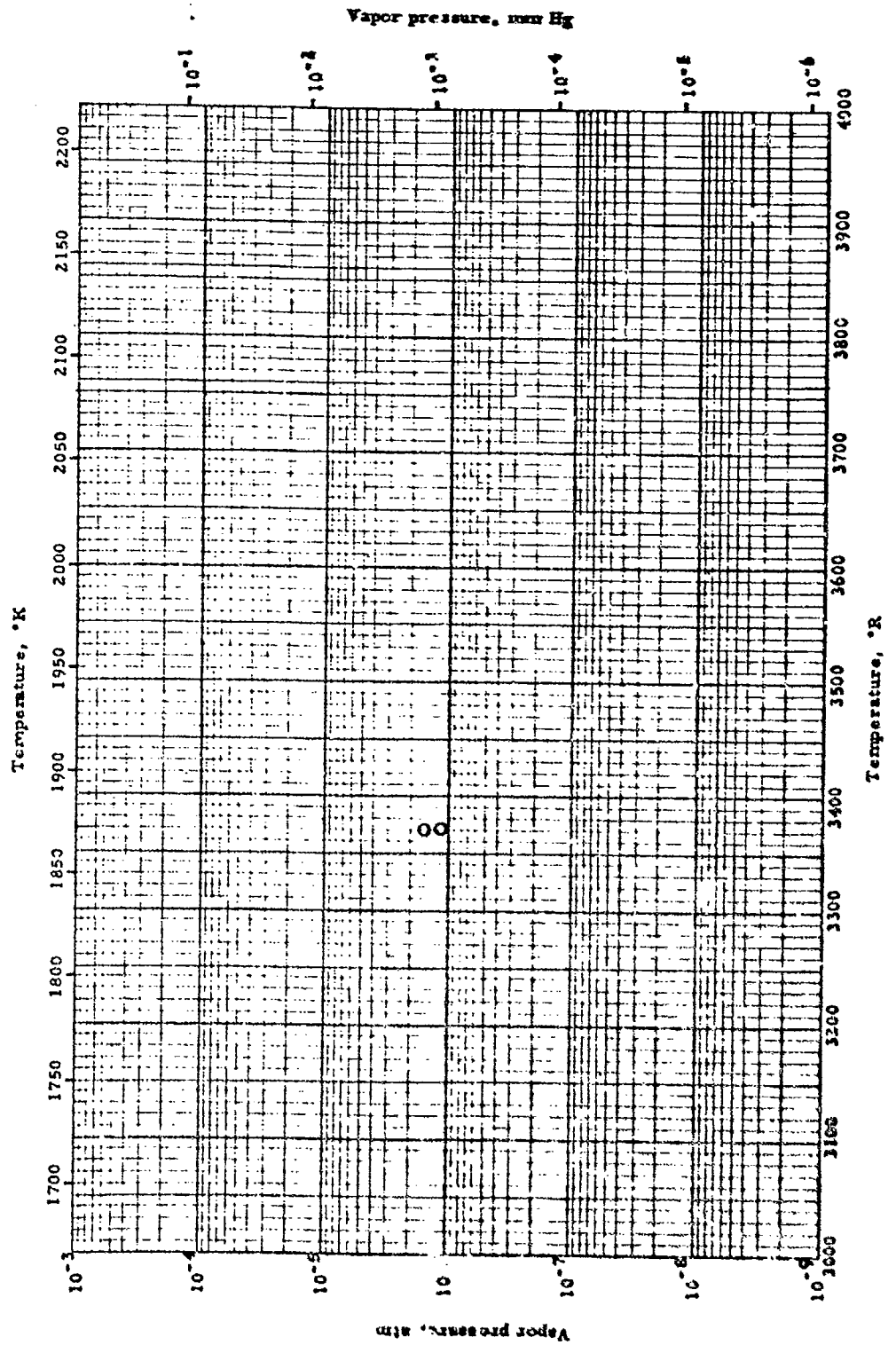
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SPECIFIC HEAT -- VANADIUM OXIDE

SPECIFIC HEAT -- VANADIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °C	Material Composition	Test Method	Remarks
O	OTT, R. L.	54-135	540-2700	98.2% pure VO_2 , small quantity of V_2O_5	Drop method	Computed from $C_p = 11.32 + 3.22 \times 10^{-3} T - 1.26 \times 10^{-5} T^2$ (T in °K). Mean deviation of exp. values of enthalpy $\pm 0.2\%$ from values computed by above equation
□	FOUR, M., Goldstaub, S. et al.	52-132	418-1012	V_2O_5	Meas. temp. rise of sample for known heat input in adiabatic calorimeter, shielded and in vacuum, calibrated with KCl	Auth. est. accuracy $\pm 3\%$



59-208

WADC TR 58-476

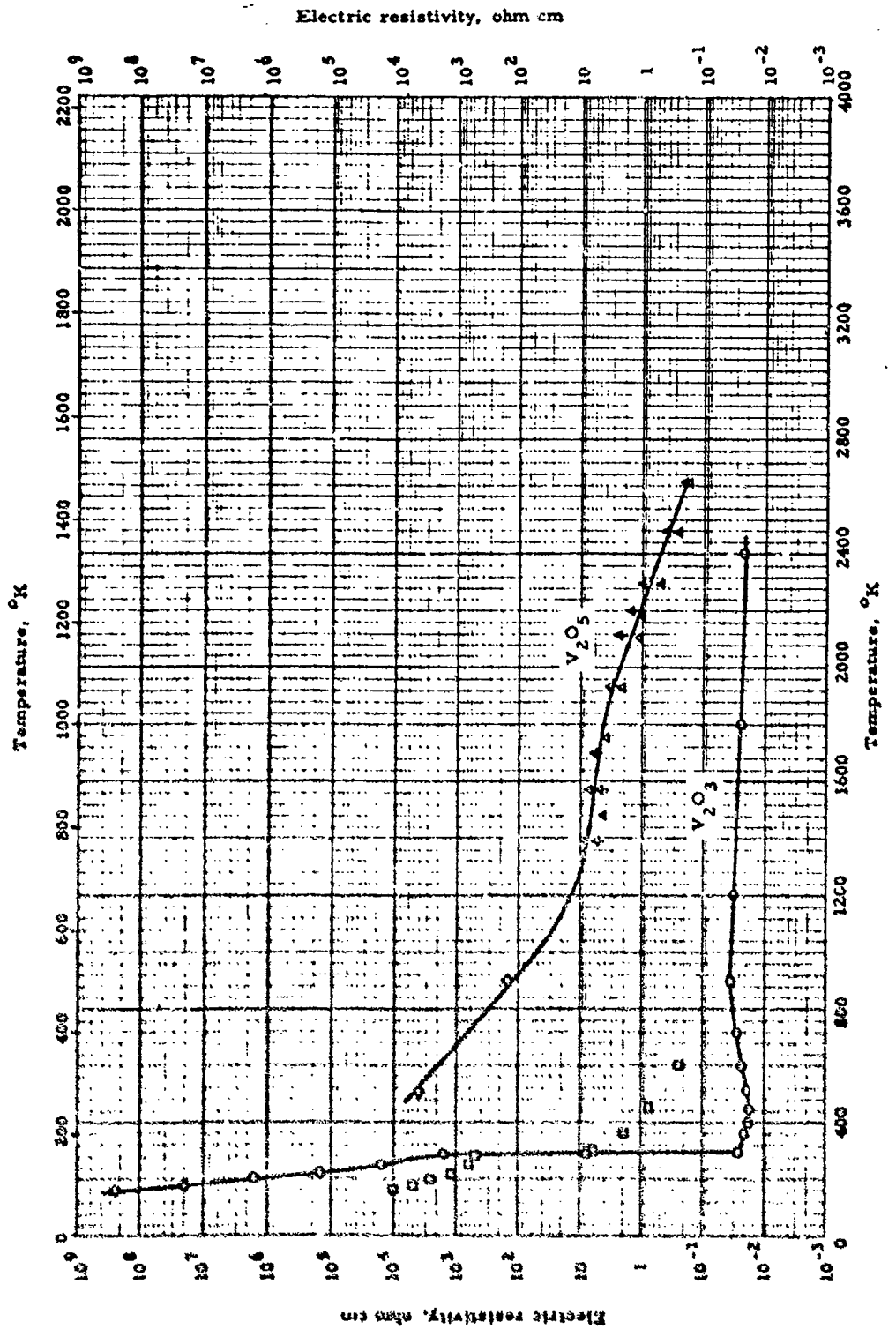
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VAPOR PRESSURE -- VANADIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Inghram, M. G., Merkowitz, J., and Chapman, W. A.	26-14	1759.6 - 1371.4	VO	Knudsen effusion cell	VO _(g) = VO _(s)



60-531

WADC TR 58-476

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ELECTRIC RESISTIVITY -- VANADIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Foca, W., Golitsa, E. et al.	52-132 also 49-69	164-2400	V ₂ O ₅	Potential drop in H ₂ atm.	Compressed, sintered at 1400°C
2	Ref.	52-132 also 49-69	164-4600	Same as above	Same as above	Compressed, sintered at 1800°C
3	Ekin, O. A., 2nd Zyuzov, V. L.	57-108	1392-2452	V ₂ O ₅ Russian brand (Ch. D. A.)	Bridge method at 1000 cycles; oscilloscope detector	Auth. est. accuracy + 10% Δ - heating, Δ - cooling
4	Ref. E. W. and Suber, L. L.	58-17	515-900	V ₂ O ₅ 0.01% ea. Te, Si; 0.001% ea Al, Cr, Cu.	Not given	98% of V ₂ O ₅ coarse crystal; 2% skeleton type crystal stringers

PROPERTIES OF YTTRIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	279 lb _m /ft ³	4.47 g/cm ³
Melting Point	4830°R	2683°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft³ g/cm³
 □ 278 4.46

Melting Point: °R °K
 ○ 4830 2683

Heat of Fusion: Btu/lb_m cal/g

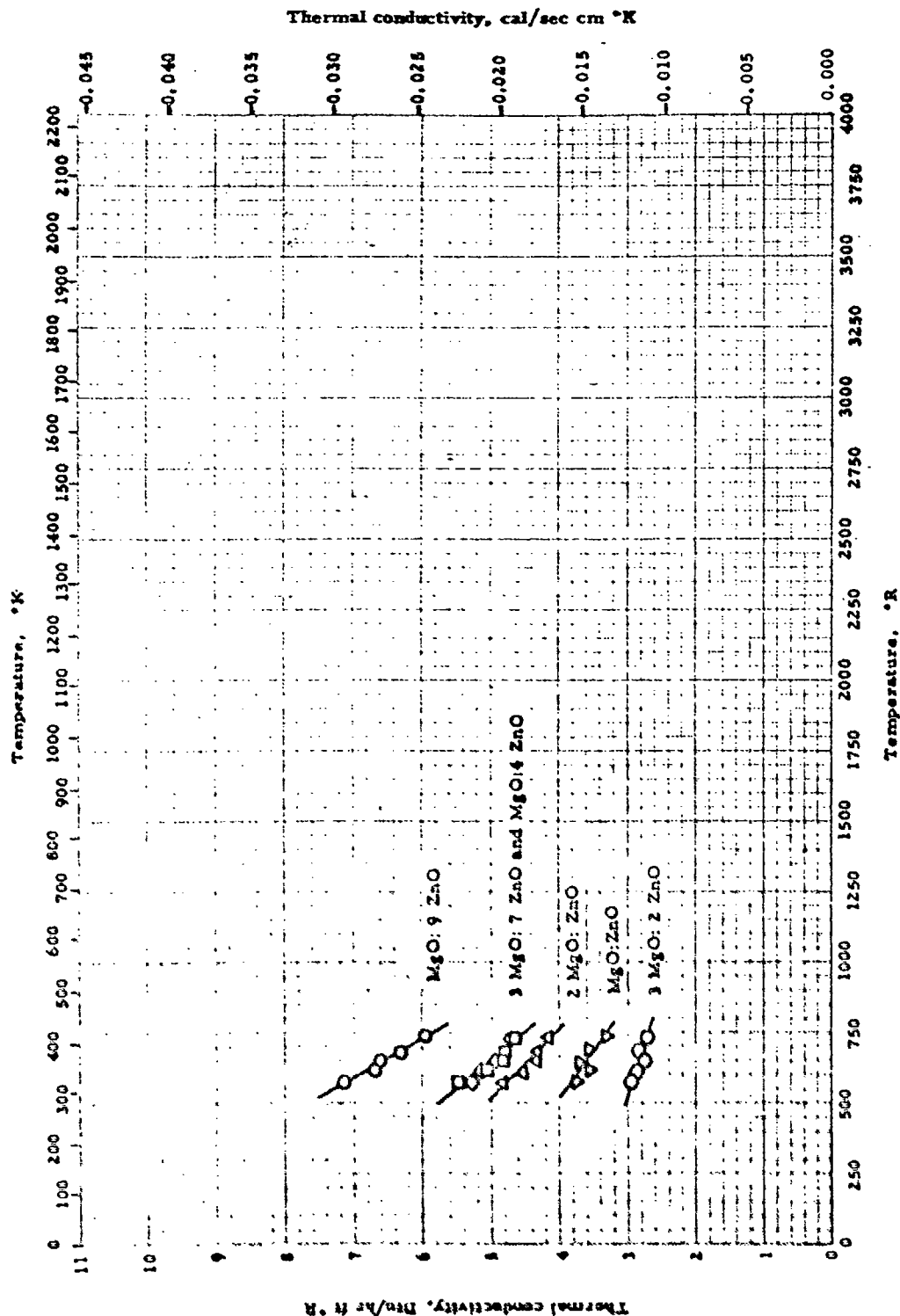
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF YTTRIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Trembo, F.	49-16	4830	Y ₂ O ₃	MP; not given	
□	Curtis, C.E.	57-84	Room	Y ₂ O ₃ ; <0.1% ea. Nb, Cr, Pb, Zr; <0.05% ea. Al, Ca, Cu, Ni, Si; <0.04% ea. Ca, Ce; <0.03% Na; <0.02% ea. Ba, Fe, Mg, Mn, Mo, Ti, V; <0.01% ea. K, Li, Pr, Nd, Sm, Tb, Ho; <0.004% La; <0.002% ea. Eu, Gd, Er, Tm, Yb, Re; porosity = 0.3%	p; weight and volume by water displacement	Fired at 1800°C



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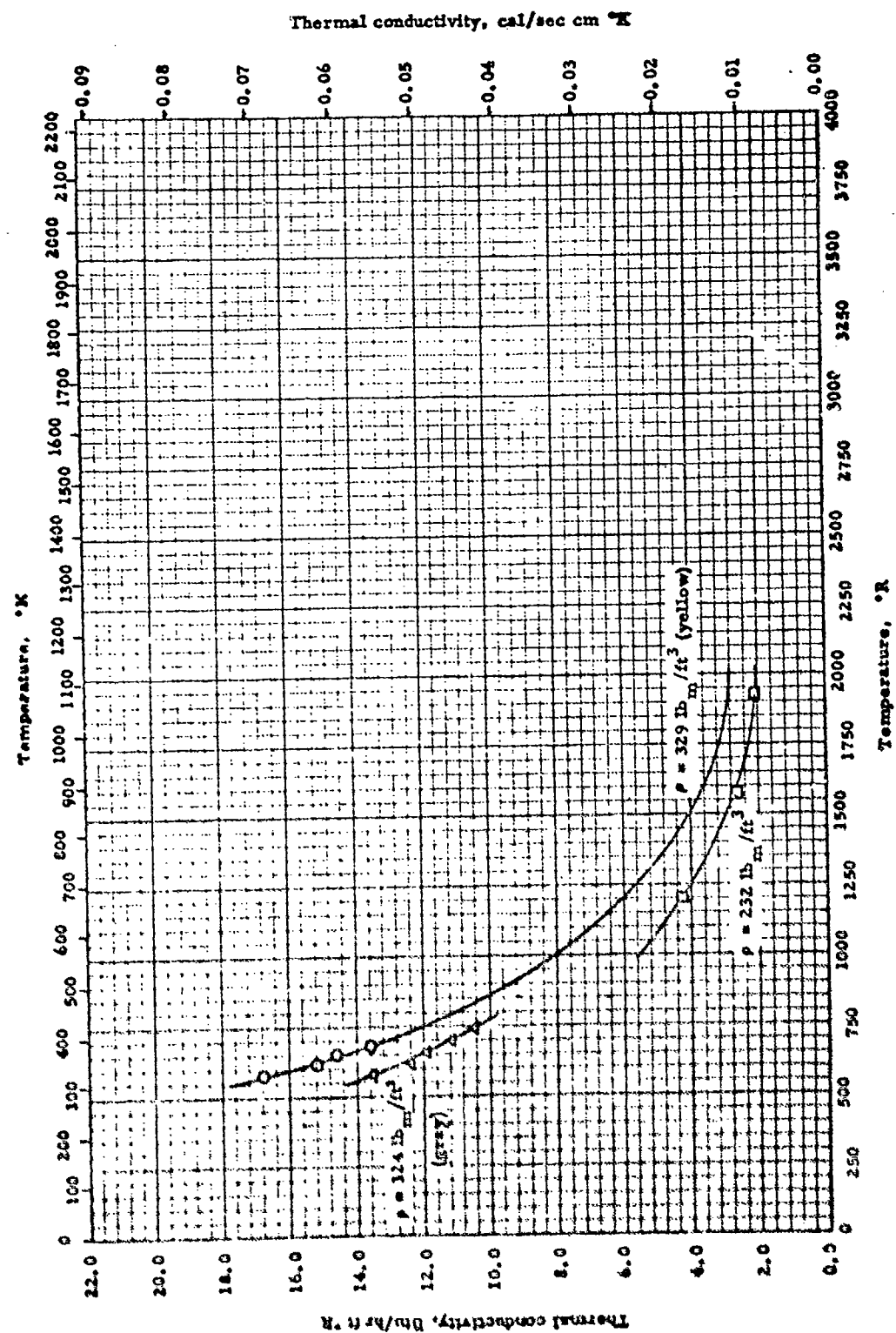
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Thermal conductivity -- ZINC OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE-MAGNESIUM OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
33-5	New Jersey Ceramic Research Division	33-5	574-742	MgO: 9 ZnO: 94.73% ZnO; 5.22% MgO; water absorption: 0.029%; $\rho = 326 \text{ lb}_m/\text{ft}^3$	Comparative; rec.	Fired 2 hr. at 3500°F; tested in vacuum
33-5	Id.	33-5	573-736	MgO: 4 ZnO: 82.98% ZnO; 11.02% MgO; water absorption: 0.015%; $\rho = 313 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
33-5	Id.	33-5	575-738	3 MgO: 7 ZnO: 82.49% ZnO; 17.51% MgO; water absorption: 0.003%; $\rho = 312 \text{ lb}_m/\text{ft}^3$	Same as above	Fired 2 hr. at 2600°F; tested in vacuum
33-5	Id.	33-5	572-738	2 MgO: 3 ZnO: 75.17% ZnO; 24.83% MgO; water absorption: 0.01%; $\rho = 303 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
33-5	Id.	33-5	577-744	MgO: ZnO: 66.87% ZnO; 33.13% MgO; water absorption: 0.040%; $\rho = 304 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
33-5	Id.	33-5	524-736	3 MgO: 2 ZnO: 57.37% ZnO; 42.63% MgO; water absorption: 0.006%; $\rho = 290 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above



THERMAL CONDUCTIVITY -- ZINC OXIDE (ZnO)

REFERENCE INFORMATION

$\frac{W}{L}$ bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	53-5	575-687	Yellow, $\rho = 330 \text{ lb}_m/\text{ft}^3$	Comparative; rods	Fired at 2850°R for 1 hr.
A	New Jersey Ceramic Research Station	53-5	580-744	Gray, $\rho = 325 \text{ lb}_m/\text{ft}^3$	Comparative; rods	Fired at 3010°R for 1 hr.
□	Kingery, W.D. and Franci, J.	54-1 also 53-65	852-1932	$\rho = 232 \text{ lb}_m/\text{ft}^3$; porosity = 34%	Ellipsoidal envelope	Prepared by calcining c.p. ZnO at 900°C and slip casting.



ELECTRIC RESISTIVITY -- ZINC OXIDE

ELECTRIC RESISTIVITY -- ZINC OXIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Nakhotova, A. P.	56-73	1130-2120	ZnO	Potential drop. Sample temp. by Mo-Ni thermocouple. In range 800-900°C, optical pyrometer was also used	Formed from chemically pure materials; baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace; meas. under 10 ⁻⁵ mm Hg, const. current
□	Miller, P. H.	41-27	557-2000	ZnO	Potential drop	Values unstable, depend on past history of sample
Δ	Cowan, J. A.	57-185	140-820	ZnO	Wheatstone bridge	Soaked for 16 hr. at 1300°C, quenched to various temps. for various samples; density by changed electric resistivity by factor of 10, so only curve shape of value. Not plotted.

PROPERTIES OF KYANITE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3660°R	1930°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

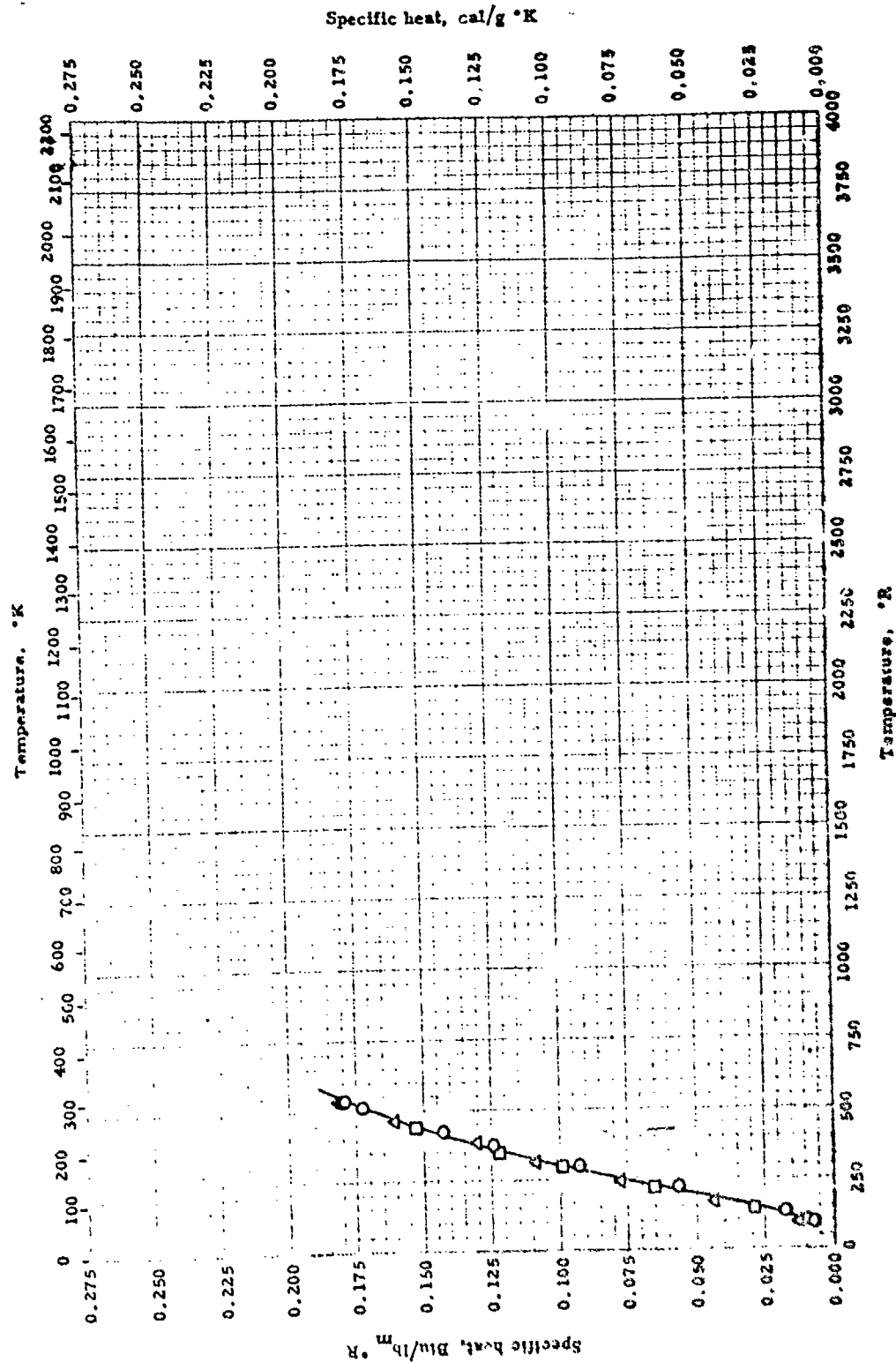
REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R O 3660 ± 54	°K 1930 ± 30
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF KYANITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Shedy, J. P. and Kellison, J. H.	50-67	3600-3720	Fired kyanite containing 3% magnesia	MP: determined by re- peated freezing and melting of sample. Temp. measured by op- tical pyrometer sighting on black body cavity	

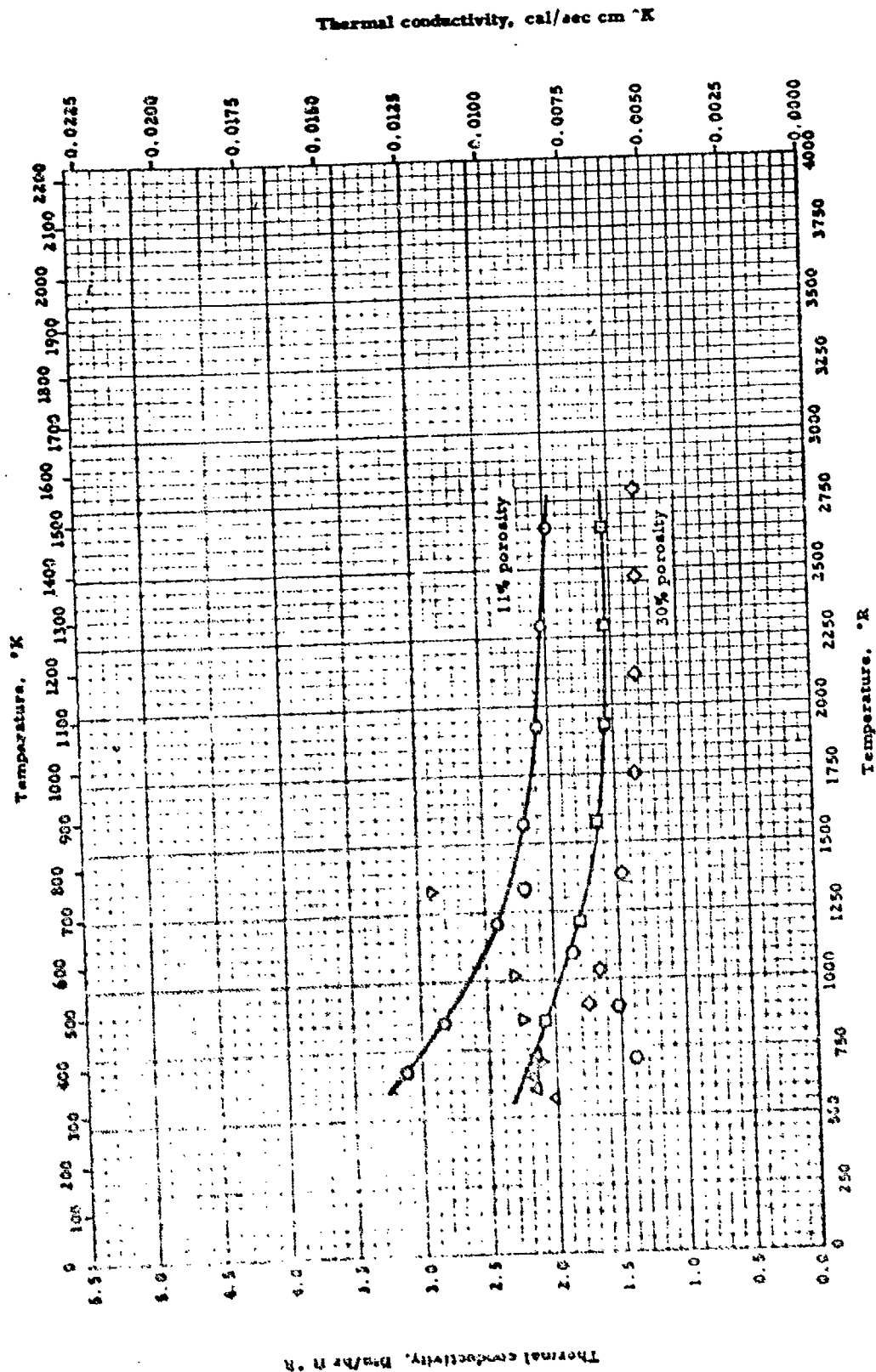


SPECIFIC HEAT -- MINERAL ALUMINO-SILICATE

SPECIFIC HEAT -- MINERAL ALUMINO-SILICATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	Todd, S. S.	20-18	99-537	Kyanite: 63.2% Al_2O_3 ; 36.90% SiO_2 ; 0.10% Fe_2O_3 ; 0.05% CaO	Guarded sample	
C	Ibid.	52-18	99-537	Andalusite: 63.15% Al_2O_3 ; 36.84% SiO_2 ; 0.11% Fe_2O_3 ; 0.02% CaO ; <0.01% ea. TiO_2 , MgO , MnO	Same as above	
A	Ibid.	52-13	98-537	Sillimanite: 61.8% Al_2O_3 ; 36.44% SiO_2 ; 0.98% Fe_2O_3 ; 0.28% P_2O_5 ; 0.24% MgO ; 0.14% FeO ; 0.07% CaO ; 0.04% ea. N_2O , F ; <0.01% N_2O	Same as above	



Thermal Conductivity of Mullite

REFERENCE INFORMATION

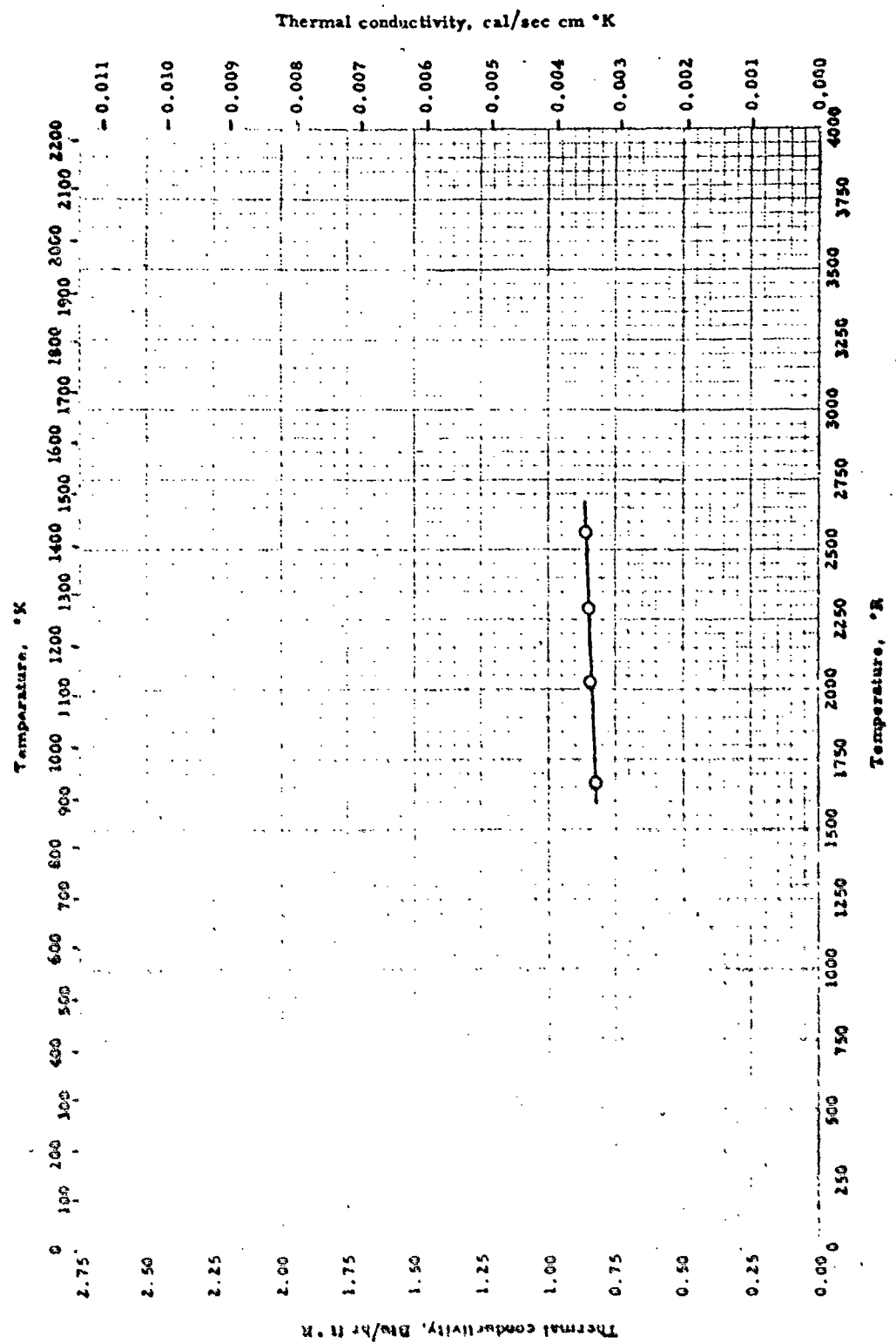
Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
1	McGarry, W. D., and Framm, J.	54-1	673-2452	54.6% Al_2O_3 ; 45.4% SiO_2 (calc); Theoretical $\rho = 197 lb/ft^3$; bulk $\rho = 174 lb/ft^3$; porosity 11.4%	Ellipsoidal envelope	Author quotes theoretical ρ for $Al_2O_3 \cdot SiO_2$ as $197 lb/ft^3$
2	Idol.	66-1	632-2432	54.6% Al_2O_3 ; 45.4% SiO_2 ; Theoretical $\rho = 197 lb/ft^3$; bulk $\rho = 138 lb/ft^3$; porosity 29.8%	Same as above	
3	New Jersey-Ceramtec Research Station	54-69	567-727	Mullite	Comparative, rod in vacuum	
4	Hartman, F. M., and McGarry, W. D.	53-75	670-2780	$Al_2O_3 \cdot 2SiO_2$, pure crystalline	Ellipsoidal envelope, temp. by thermocouple	Grind 24 hr., electromagnetic separation and HCl treatment, dense pieces fired at $1780^\circ C$. Auth. est. accuracy $\pm 8\%$
5	Kasap, V. J.	43-II	705-1340	Mullite, polycrystalline	Comparative, rods. Temp. by Chromel-Const. thermo- couple	Electrocast, needles well aligned. Mean, parallel to c - axis
6	Idol.	43-II	705-1340	Same as above	Same as above	Same as above except mean, perpendicular to c - axis

59-87

WADC TR 58-476

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VII - B

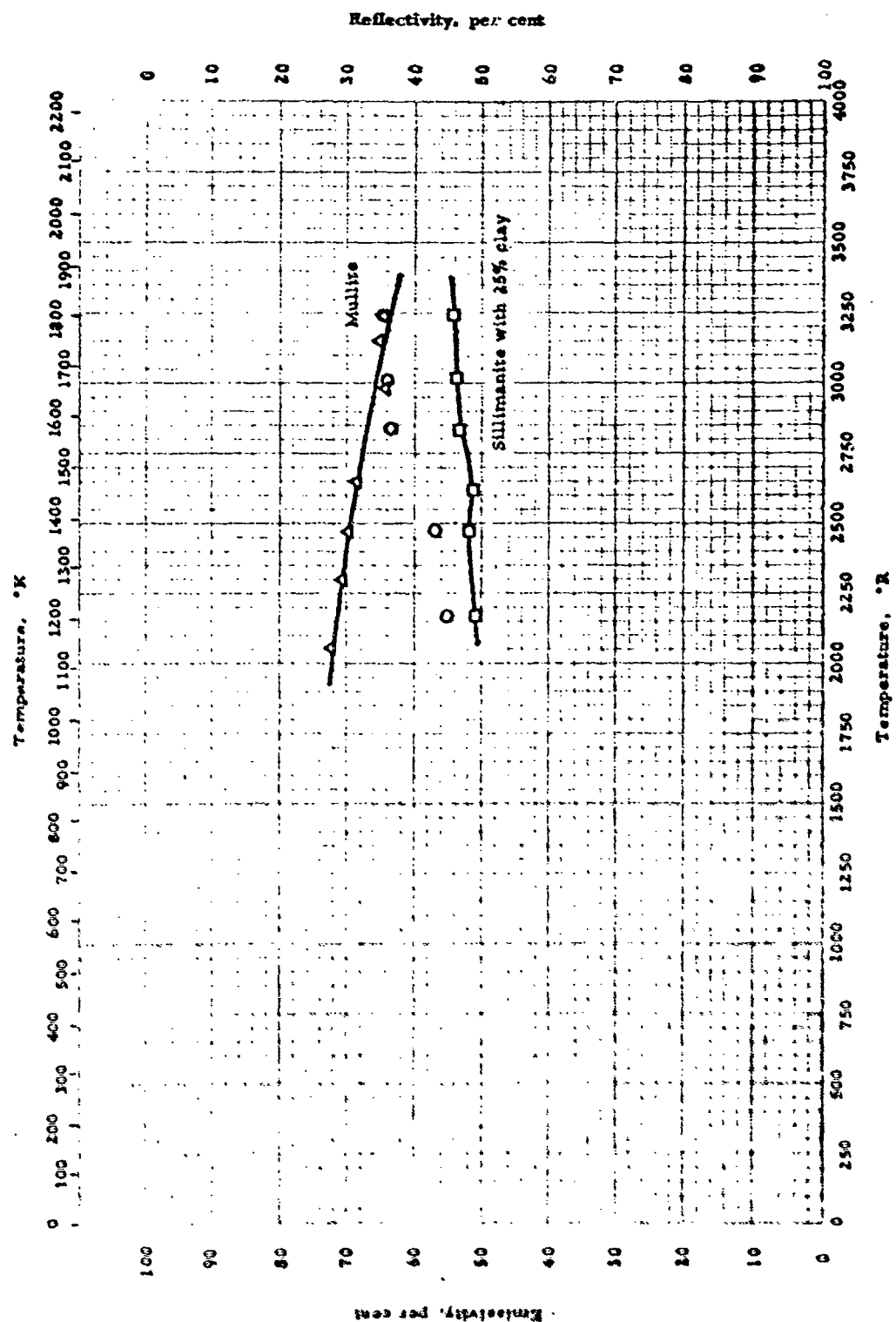


Thermal conductivity -- SILLIMANITE BRICK

THERMAL CONDUCTIVITY -- SILLIMANITE BRICK

REFERENCE INFORMATION

$\frac{K}{\text{in}^2 \cdot \text{hr} \cdot ^\circ\text{F}}$	Investigator	Ref.	Range, $^\circ\text{R}$	Material Composition	Test Method	Remarks
0	Clements, J. F. and Vyas, J.	57-26	1662-2562	57.34% Al_2O_3 ; 39.64% SiO_2 ; 1.26% TiO_2 ; 0.70% Fe_2O_3 ; 0.34% K_2O ; 0.25% Na_2O ; 0.24% MgO ; 0.20% CaO ; 0.13% loss on ignition. Bulk $\rho =$ 144 lb_m/ft^3 (cf. theor. $\rho = 185$); ap- parent porosity = 22.2%	Not described; appa- tus of Brit. Ceramic Research Assoc.	Auth. est. accuracy $\pm 5\%$



EMISSION -- ALUMINOSILICATE

EMISSIVITY -- ALUMINOSILICATE

REFERENCE INFORMATION

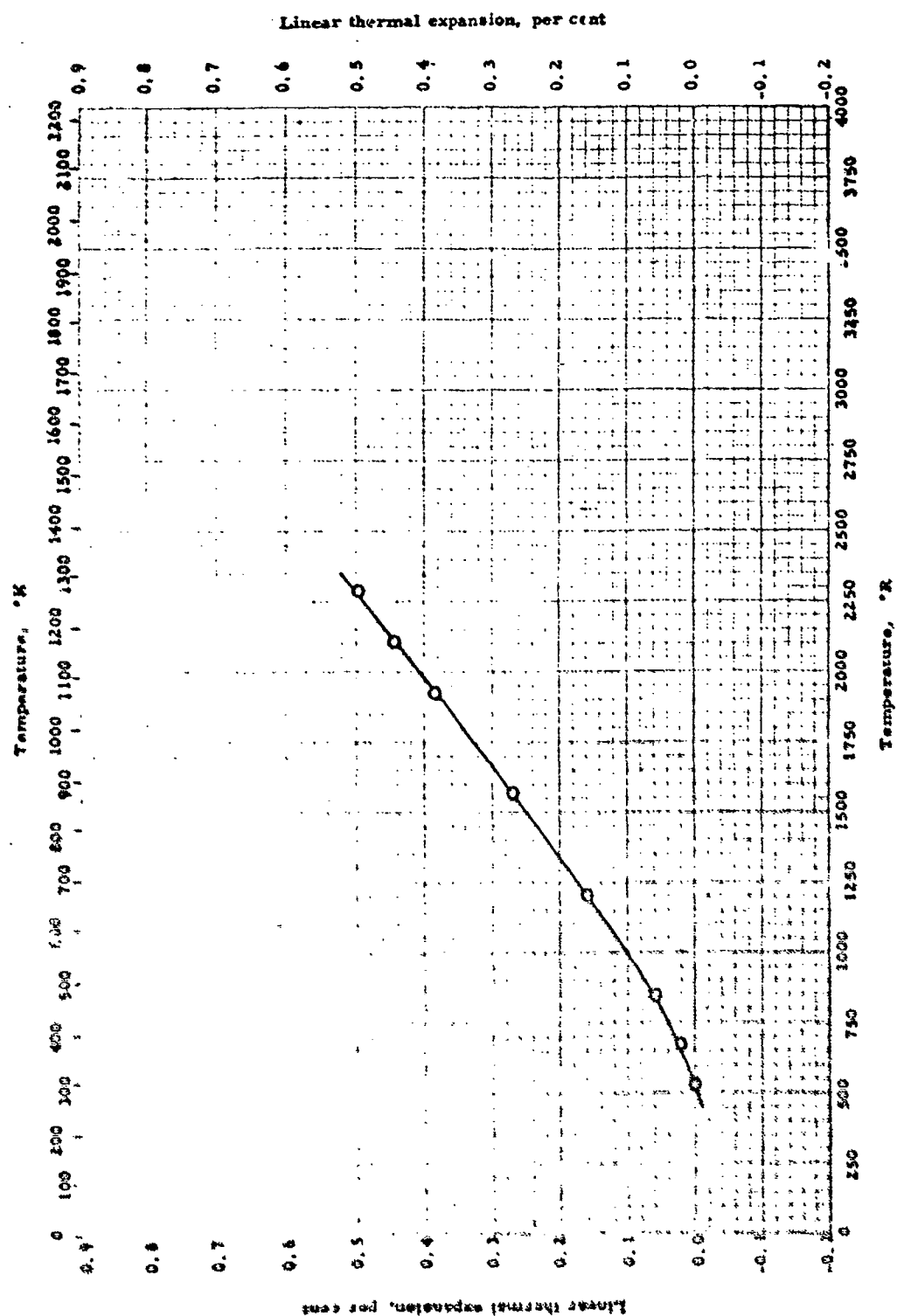
Sym. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Pattison, J. R.	55-86	2166-3246	Sillimanite with 25% clay binder	Total normal emissivity; radiant heat meas. with Hilger thermopile. Temp. by optical pyrometer sighting on black body cavity	Before firing
□	Ibid.	55-86	2166-3246	Same as above	Same as above	After firing
Δ	Ibid.	55-86	2058-3156	Mullite	Same as above	

59-335

WADC TR 58-476

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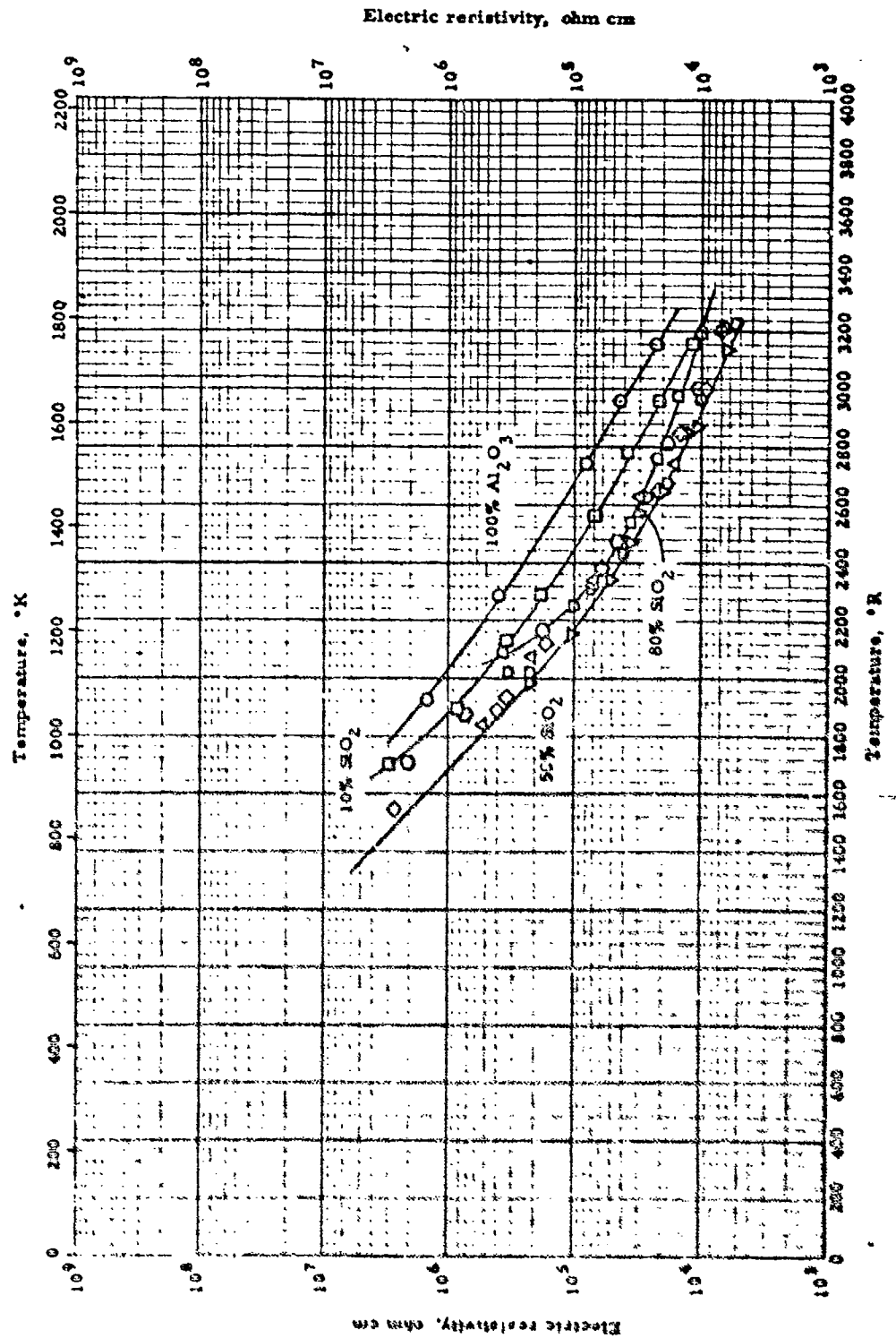


LINEAR THERMAL EXPANSION -- MULLITE

LINEAR THERMAL EXPANSION -- MULLITE

REFERENCE INFORMATION

Temp Unit	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	McKinstry, H. A., Mocker, C. F. et al.	49-15	528-2292	1 Al ₂ O ₃ · 2SiO ₂	Not given	



ELECTRIC RESISTIVITY -- MINERAL ALUMINOSILICATE

ELECTRIC RESISTIVITY -- MINERAL ALUMINOSILICATE

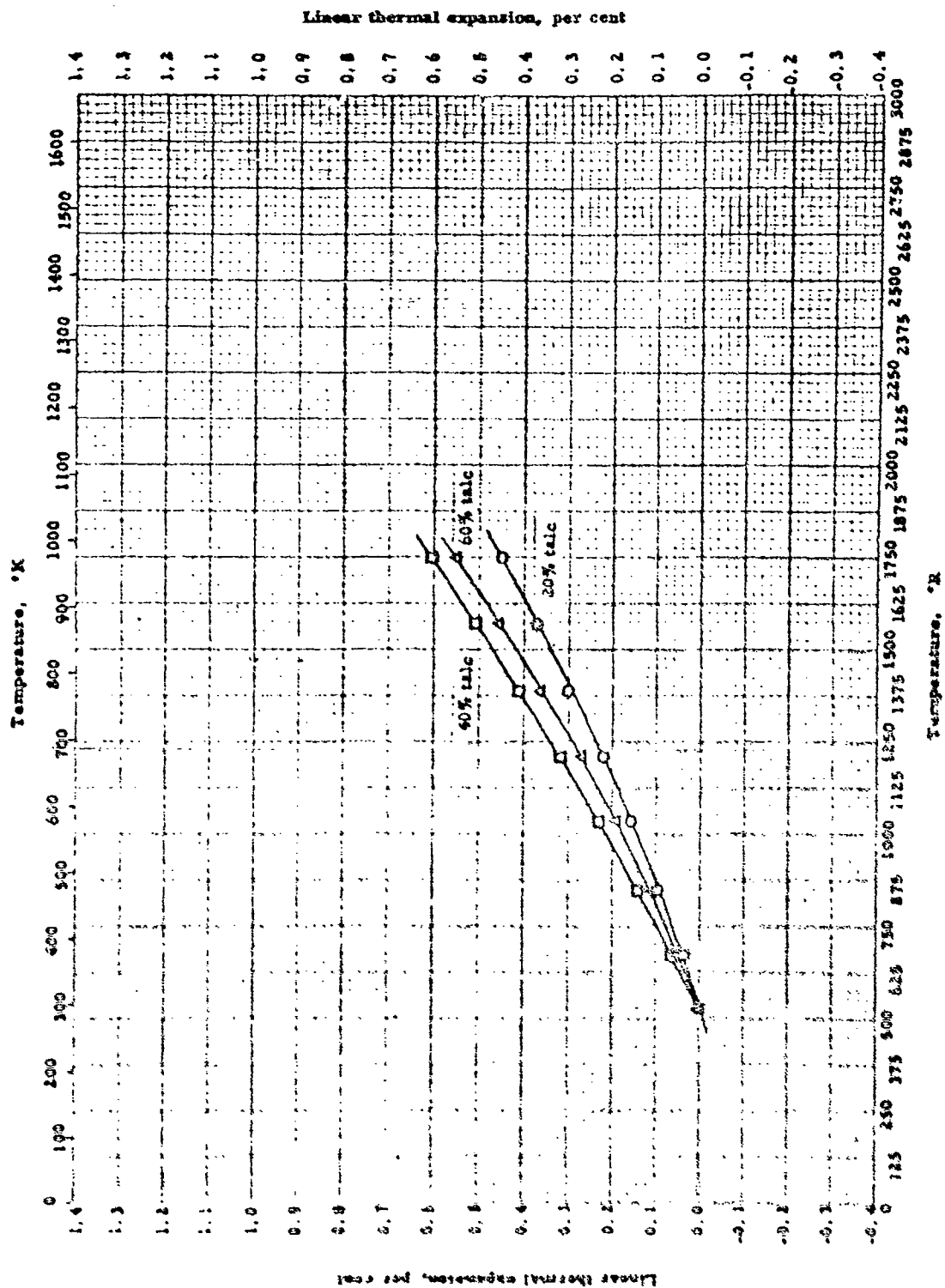
REFERENCE INFORMATION

Spec. No.	Investigator	Ref.	Range, Ω	Material Composition	Test Method	Remarks
Q	Monnier, J. R. and Henry, E. C.	53-95	1432-1154	100% Al_2O_3 ; Sintered; 17% porosity	Wheatstone bridge	Prepared from acid treated Al_2O_3 ; fired 10 hr. at 1500°C
Q	ibid.	53-95	1698-1156	90% Al_2O_3 ; 10% SiO_2 ; Sintered; 35-37% porosity	Same as above	Prepared from acid leached pottery flint and acid treated Al_2O_3 ; fired 10 hr. at 1500°C
A	ibid.	53-95	1842-1110	80% Al_2O_3 ; 20% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
Q	ibid.	53-95	1154-1110	70% Al_2O_3 ; 30% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
D44.	ibid.	53-95	1715-2994	60% Al_2O_3 ; 40% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
V	ibid.	53-95	1984-1114	50% Al_2O_3 ; 50% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
Q	ibid.	53-95	1787-1124	40% Al_2O_3 ; 60% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
Q	ibid.	53-95	1022-1110	30% Al_2O_3 ; 70% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above
Q	ibid.	53-95	1094-1192	20% Al_2O_3 ; 80% SiO_2 ; Sintered; 35-37% porosity	Same as above	Same as above

59-408

WADC TR 56-476

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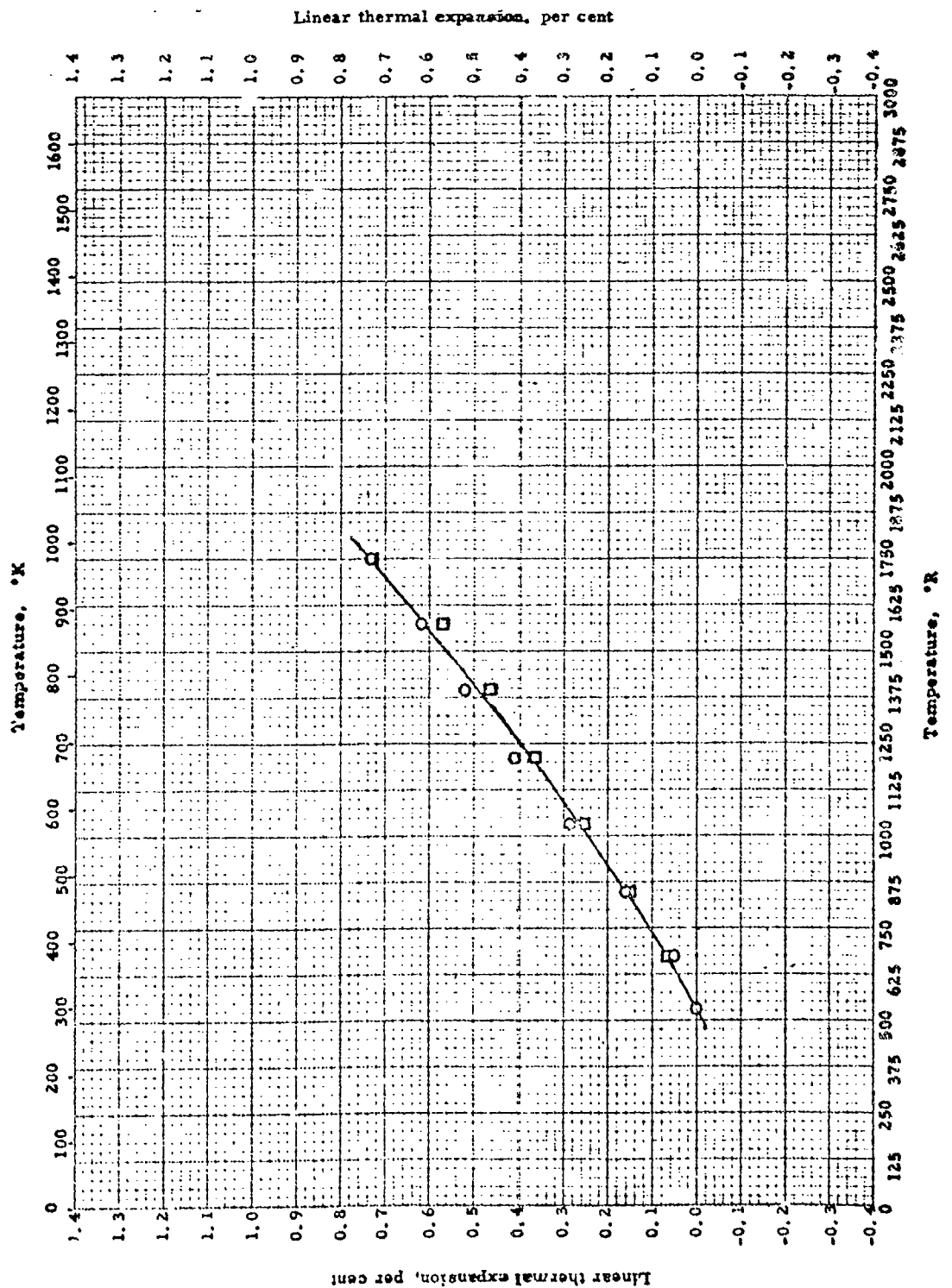


VII - B -

LINEAR THERMAL EXPANSION -- BARIUM CALCIUM SILICATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
55-22	New Jersey Ceramic Research Station	55-22	672-1732	60% Wollastonite; 20% Sierra high grade talc; 10% BaCO ₃ ; 10% E.P.K. clay	Silica tube dilatometer	Tested at 2-3°C/min. rise
55-22	226A.	55-22	672-1732	40% Wollastonite; 40% Sierra high grade talc; 10% BaCO ₃ ; 10% E.P.K. clay	Same as above	Same as above
55-22	226D.	55-22	672-1732	40% Sierra high grade talc; 20% Wollastonite; 10% BaCO ₃ ; 10% E.P.K. clay	Same as above	Same as above



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WADC TR 58-476

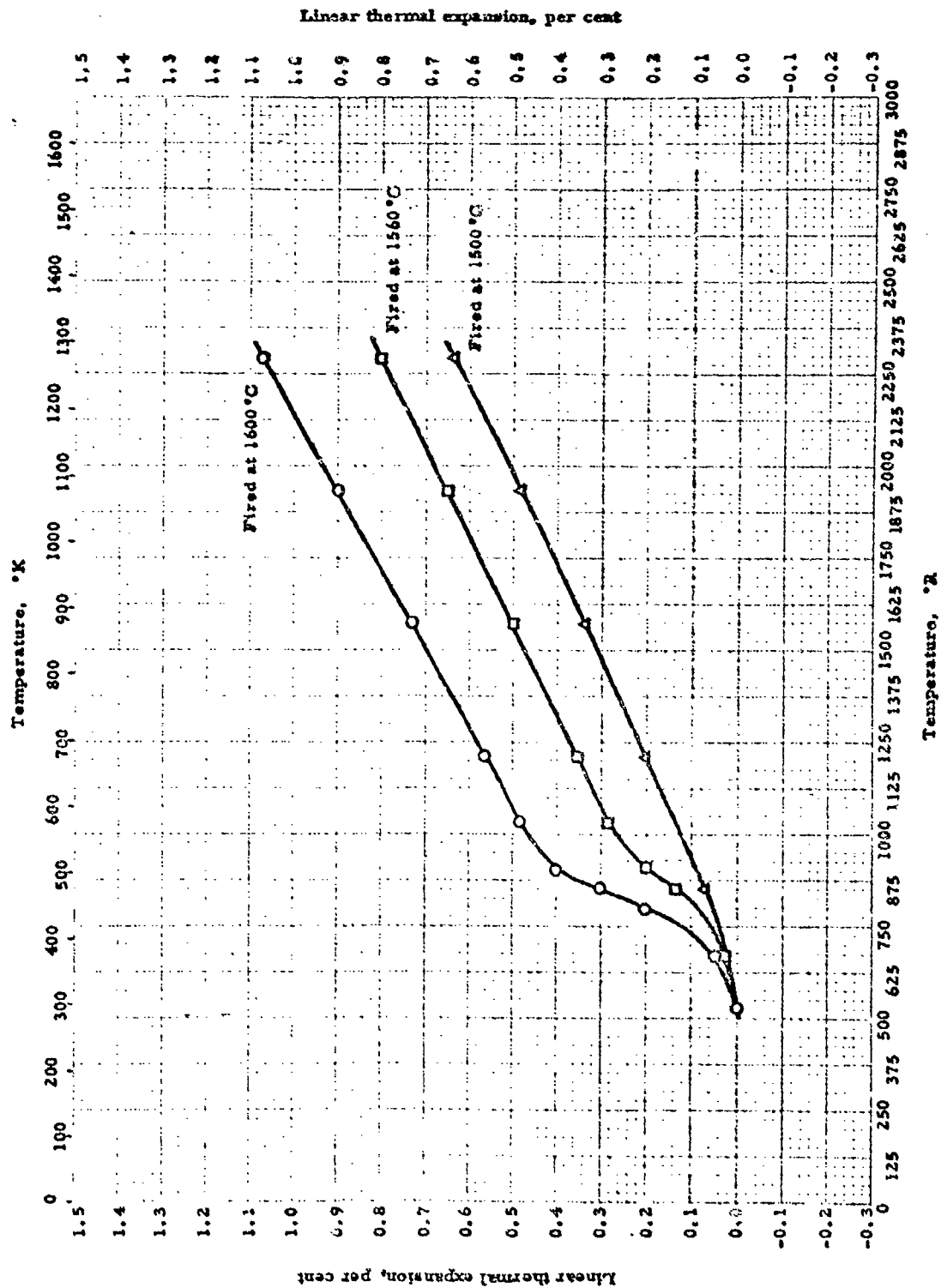
467

VII - B - 2

LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM SILICATE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
55-22	New Jersey Ceramic Research Station	672-1752	54.6% BaCO ₃ ; 31.6% talc; 13.8% MgO; final product approx. BaO · 3MgO · SiO ₂ ; $\rho = 210 \text{ lb}_m/\text{ft}^3$	Silica tube dilatometer	Fired at 2660°F; tested at 2-3°C/min. rise
55-22	Ibid.	672-1752	58% talc; 33.7% BaCO ₃ ; 8.3% MgO; final product approx. BaO · 4MgO · 3.5SiO ₂ ; $\rho = 192 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 2450°F; tested at 2-3°C/min. rise



LINEAR THERMAL EXPANSION -- BERYLLIUM SILICATE

LINEAR THERMAL EXPANSION -- BERYLLIUM SILICATE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Penn. State	48-37	528-2292	2BeO · SiO ₂ , synthetic phenacite	Not given	Decomposes at 1560°C into component oxides. Fired at 1600°C
□	Ibid.	48-37	528-2292	Same as above	Same as above	Decomposes at 1560°C into component oxides. Fired at 1560° C
Δ	Ibid.	48-37	528-2292	Same as above	Same as above	Decomposes at 1560° C into component oxides. Fired at 1500° C

59-88

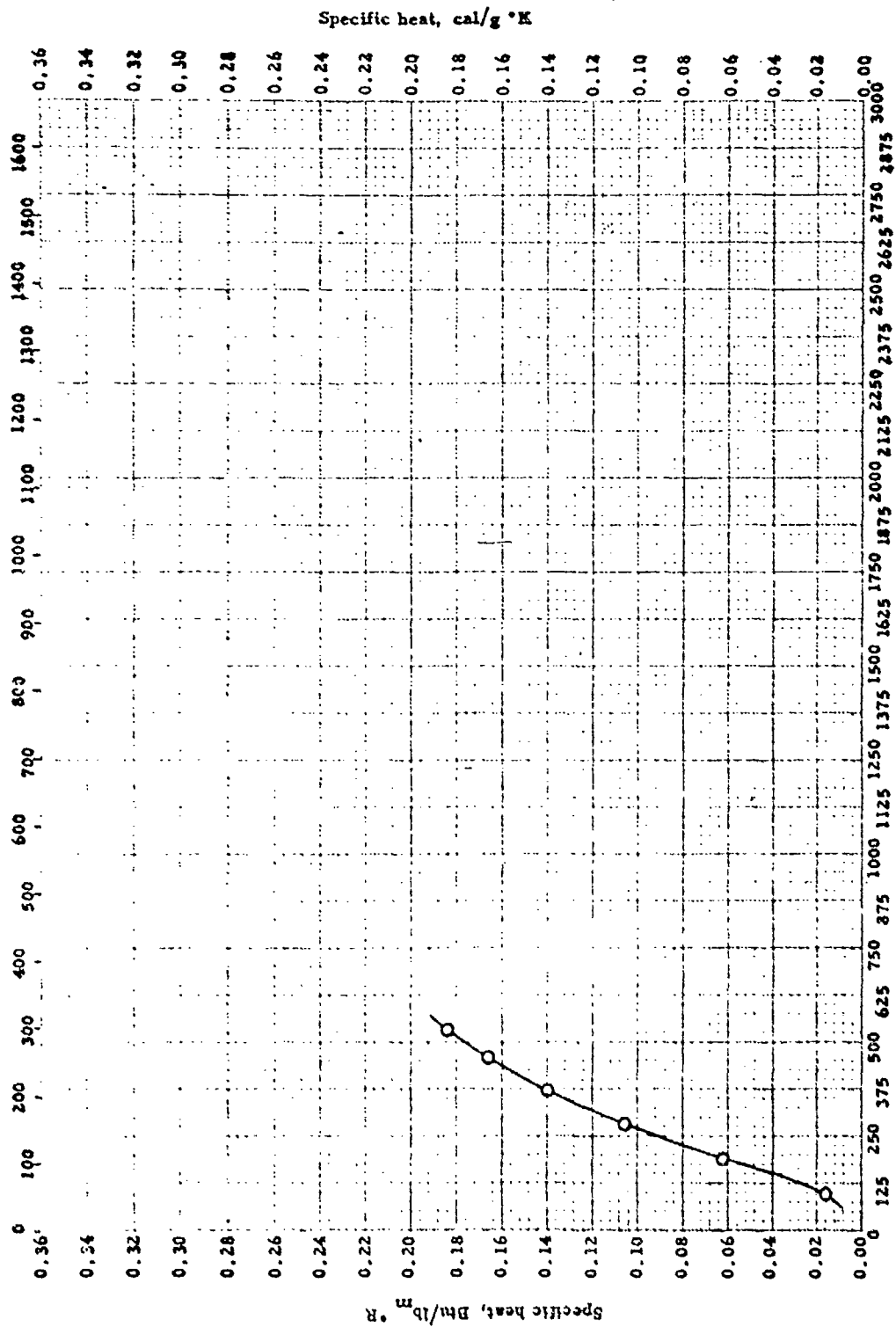
WADC TR 58-476

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Temperature, °K



Temperature, °R

SPECIFIC HEAT -- CALCIUM MAGNESIUM SILICATE

VII - B - 2-c

SPECIFIC HEAT -- CALCIUM MAGNESIUM SILICATE

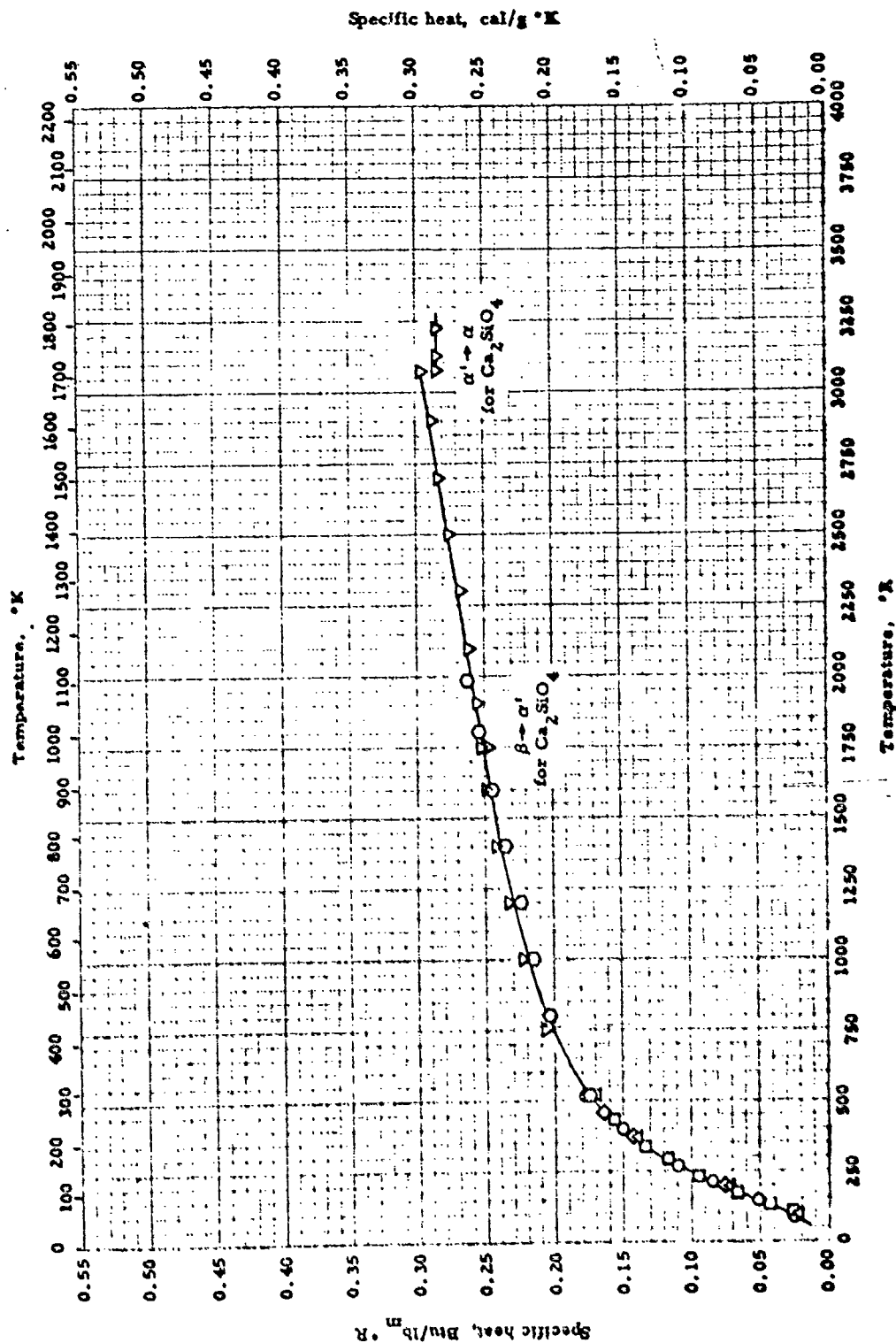
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	57-44	90-536	Calcium magnesium silicate, $\text{CaMg}(\text{SiO}_4)_2$; 54.78% silica; 25.91% lime; 18.82% magnesia; 0.66% ferric oxide; 0.07% ferrous oxide	Guarded sample	

59-446

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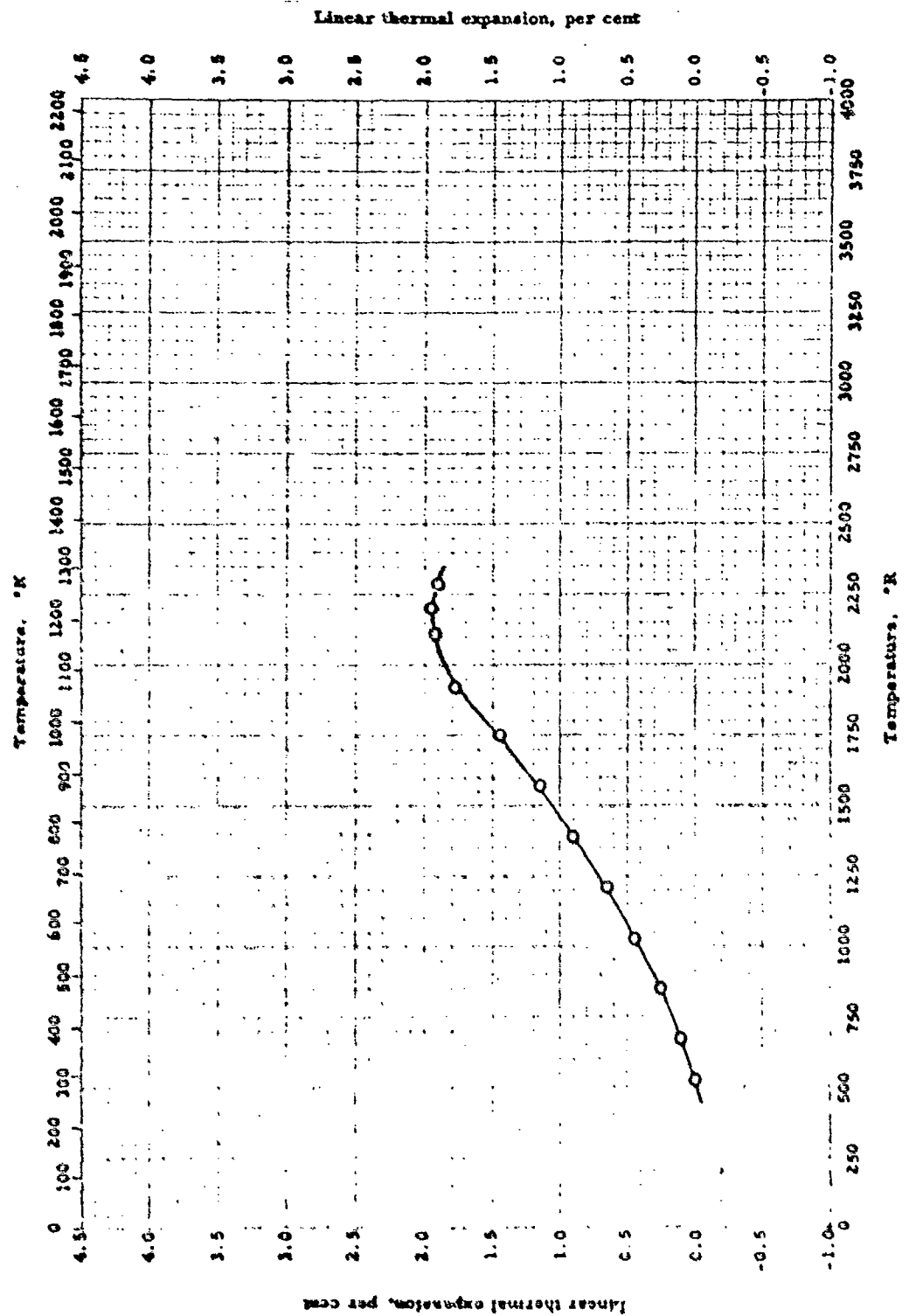
SPECIFIC HEAT -- CALCIUM SILICATE

VII - B - 2 -

SPECIFIC HEAT -- CALCIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Todd, S.S.	51-30	98-537	Tricalcium silicate, Ca_3SiO_5 , 73.64% CaO (cf. theor. 73.69%); 26.21% SiO_2 (cf. theor. 26.31%); 0.13% ea. Fe_2O_3 , Al_2O_3 ; 0.11% MgO ; 0.05% ignition loss	Guarded sample	
○	Ibid.	51-30	96-537	Calcium orthosilicate, crystalline Ca_2SiO_4 β -phase, 64.47% CaO (cf. theor. 65.13%); 34.62% SiO_2 (cf. theor. 34.87%); 0.32% ea. Fe_2O_3 , Al_2O_3 ; 0.14% MgO ; 0.02% ignition loss	Same as above	
△	Klug, E.C.	57-44	90-536	Calcium orthosilicate, Ca_2SiO_4 ; γ -phase	Guarded sample	
○	Ibid.	57-44	90-536	Tricalcium disilicate, $\text{Ca}_3\text{Si}_2\text{O}_7$, 58.37% lime; 41.62% silica	Same as above	
▽	Coughlin, J.P. and O'Brien, C.J.	57-87	731-1269	Calcium orthosilicate, Ca_2SiO_4 , β type, 64.47% CaO ; 34.63% silica; 0.32% Al and Fe oxides; 0.14% MgO ; 0.02% H_2O	Drop method; copper block calorimeter	
○	Ibid.	57-87	730-2004	Calcium orthosilicate, Ca_2SiO_4 , γ type, 34.88% silica	Same as above	Prepared from reagent grade calcium carbonate and silica

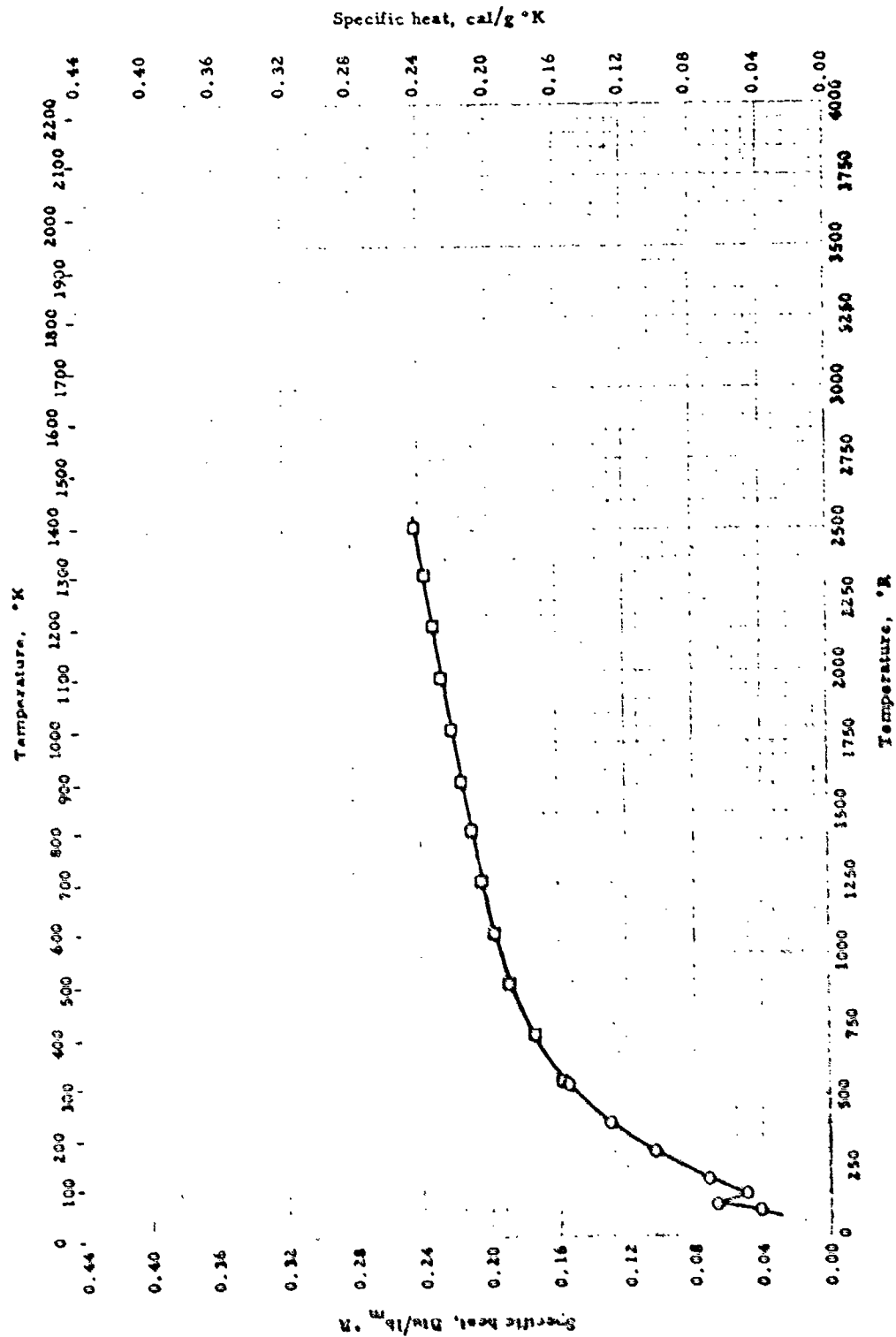


LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE ($\text{Na}_2\text{CaSiO}_4$)

LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE ($\text{Na}_2\text{CaSiO}_4$)

REFERENCE INFORMATION

Sym- bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Hummel, F. A.	49-14	528-2292	34.8% Na_2O ; 33.7% SiO_2 ; 31.5% CaO ; prepared from c.p. Na_2CO_3 , c.p. CaCO_3 , pottery flint	Fused silica dilatometer	Wet milled in acetone 12 hr., heated 50 hr. at 1100°C, pressed from 80 mesh, sin- tered 1 hr. at 1100°C



SPECIFIC HEAT -- IRON SILICATE

SPECIFIC HEAT -- IRON SILICATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
41-15	Kelley, K. K.	94-532		Fe ₂ SiO ₄ : 54.5% Fe (cf. theor. 54.8%) 29.5% silica; $\rho = 271 \text{ lb}_m/\text{ft}^3$	Guarded sample	
53-87	Orr, R. L.	540-2680		Fe ₂ SiO ₄ : 54.5% Fe (cf. theor. 54.8%) 29.5% silica; $\rho = 271 \text{ lb}_m/\text{ft}^3$	Drop method	

PROPERTIES OF MAGNESIUM SILICATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, Forsterite . . .	191 lb _m /ft ³	3.06 g/cm ³
Melting Point, Forsterite	3790°K*	2160°K*
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³	Material Composition
○	190.8 ± 0.2	3.056 ± 0.004	Forsterite 243
□	174.5 ± 0.5	2.796 ± 0.005	Steatite

<u>Melting Point:</u>	°K	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF MAGNESIUM SILICATE

REFERENCE INFORMATION

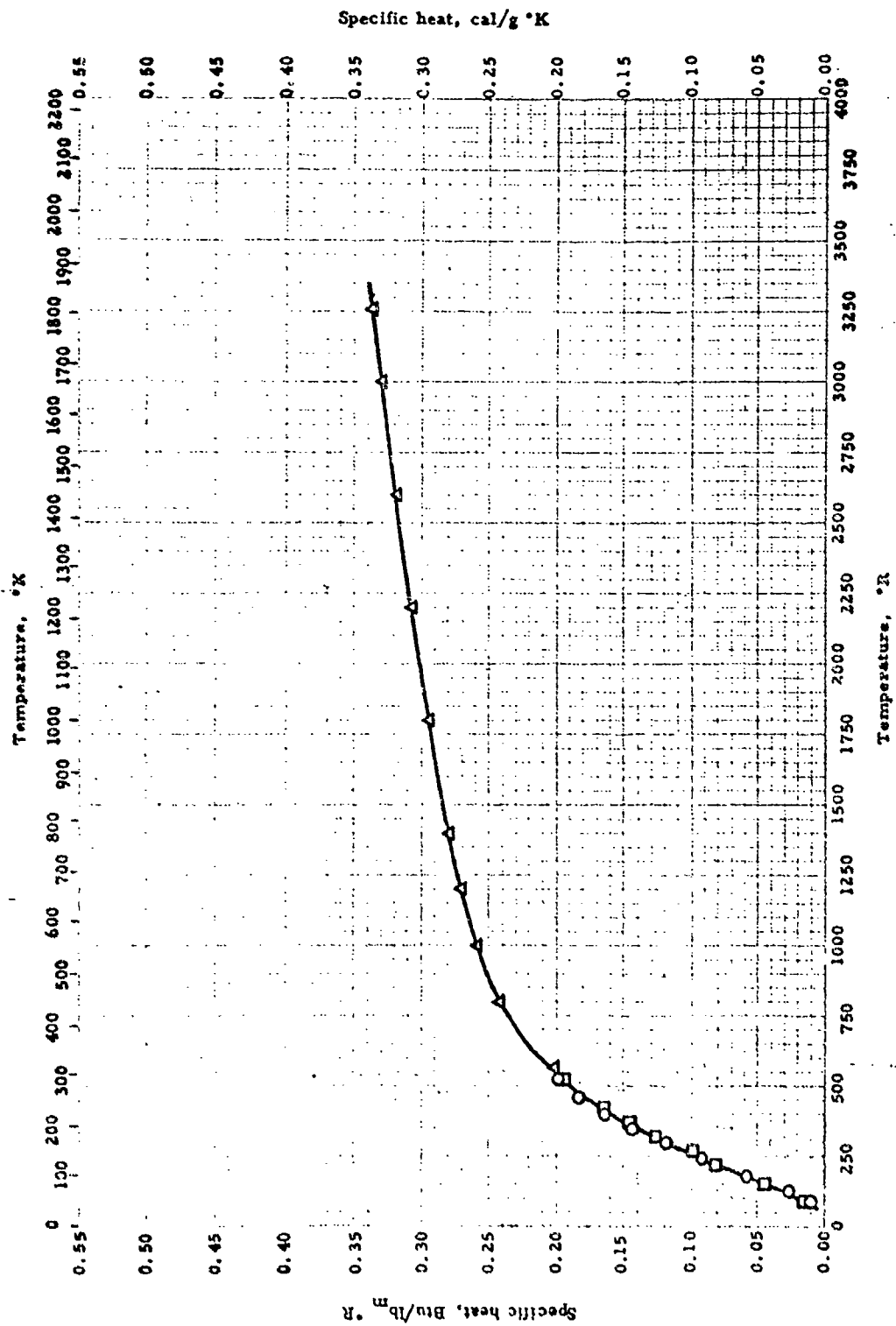
Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Oak Ridge National Laboratory	57-150	517	Forsterite 243	p: weight in air and in acetone	Measured by O. Sisman, C. D. Bopp and R. L. Towne
0	Ibid.	57-150	517	Steadite	as same as above	Same as above

60-691

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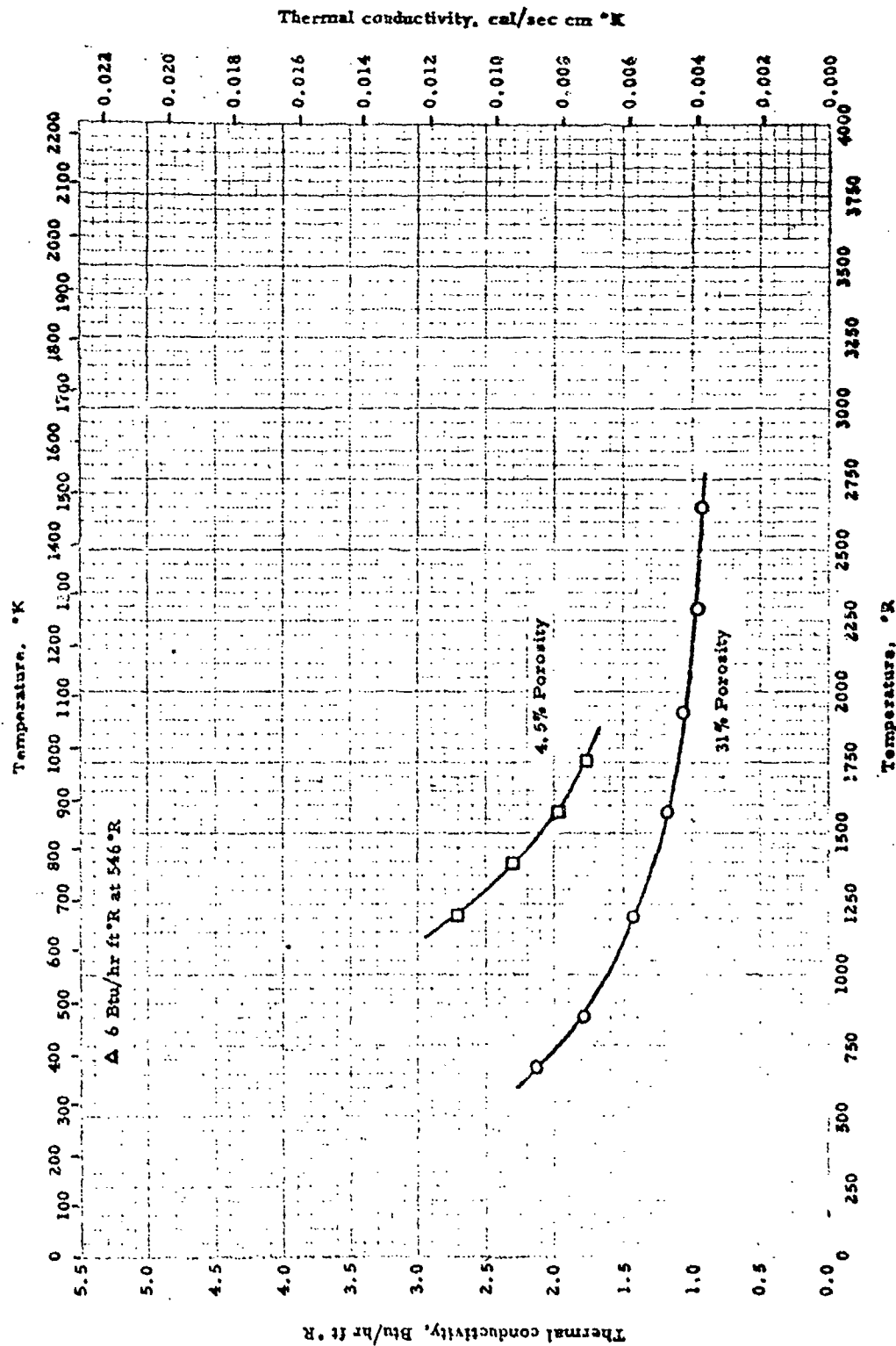


SPECIFIC HEAT -- MAGNESIUM SILICATE

SPECIFIC HEAT -- MAGNESIUM SILICATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kalley, K. K.	43-8	96-532	Magnesium orthosilicate, Mg_2SiO_4 . 98.6% Mg_2SiO_4 ; 0.8% uncombined MgO; no free silica or $MgSiO_3$	Guarded sample	Corrected for uncombined MgO. Effect on c_p : 0.31%
□	Ibid.	43-8	96-532	Magnesium metasilicate, $MgSiO_3$. 92.0% $MgSiO_3$; 5.6% Mg_2SiO_4 ; 2.4% uncombined silica	Same as above	Corrected for uncombined silica. Effect on c_p : 1.26%
Δ	Orr, R. L.	53-87	716-3254	Magnesium orthosilicate Mg_2SiO_4 ; 57.51% MgO; 42.60 SiO_2	Drop method	A th . est. scatter ± 0.4%

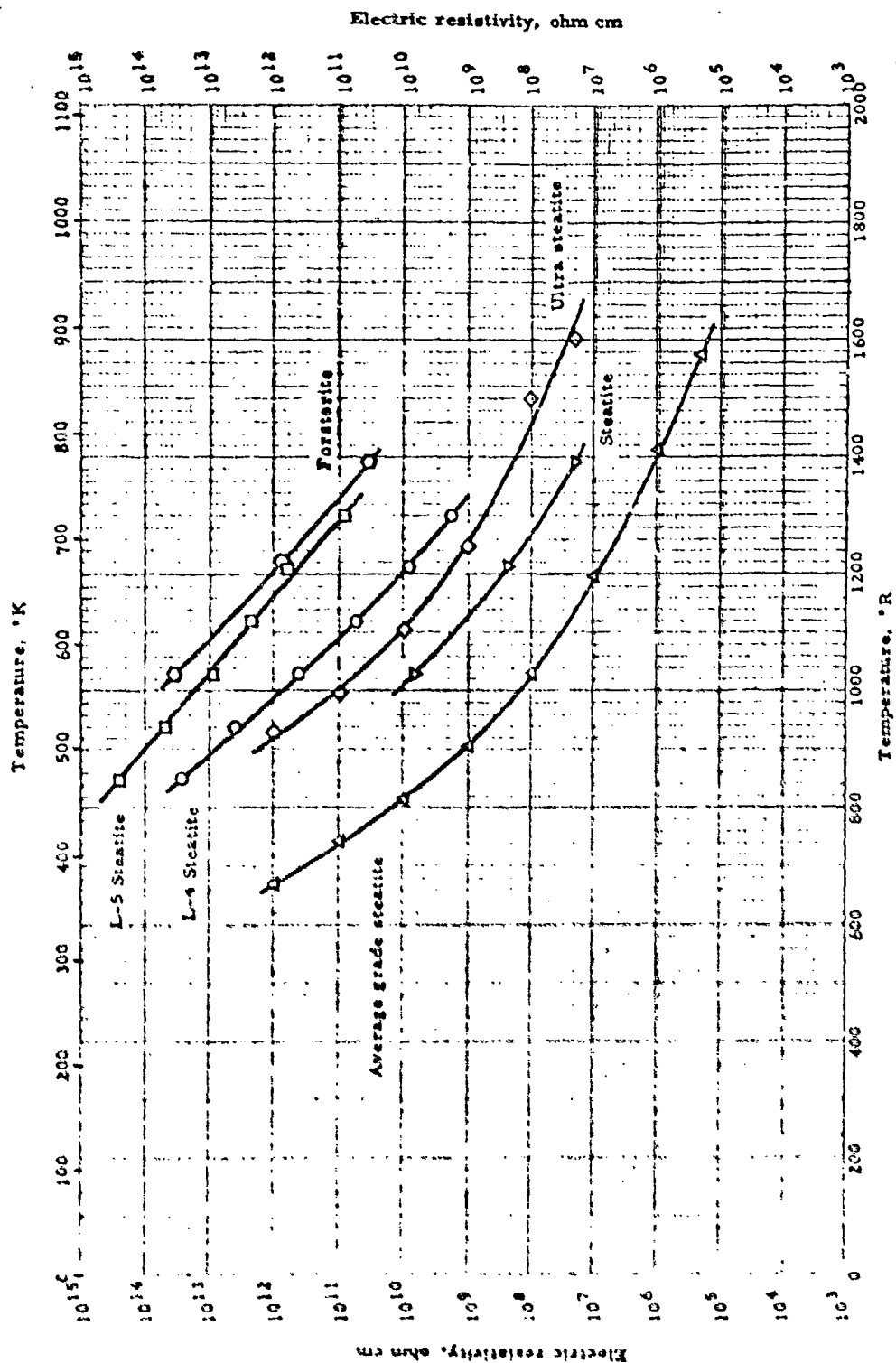


Thermal conductivity -- MAGNESIUM SILICATE

THERMAL CONDUCTIVITY -- MAGNESIUM SILICATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W.D. and Franci, J.	53-65 also 53-66 54-1	672-2652	Forsterite, Mg_2SiO_4 , 59% MgO , 41% SiO_2 ; bulk $p = 139 \text{ lb./ft}^3$ (cf. theor. $p = 200$); porosity = 31.1%	Ellipsoidal envelope	Fired at 1650 °C
□	Franci, R.K., McNamara, E.P. and Tinklepaugh, J.R.	58-7	1212-1752	Forsterite, $p = 191 \text{ lb./ft}^3$	Comparative; rods	
△	Oak Ridge National Laboratory	57-150	546	Forsterite 243,	Not described here, refers to others	Auth. est. accuracy $\pm 20\%$, Meas. by O. Sigman, C. D. Ropp and R. L. Towne



60-572

WADC TR 58-476

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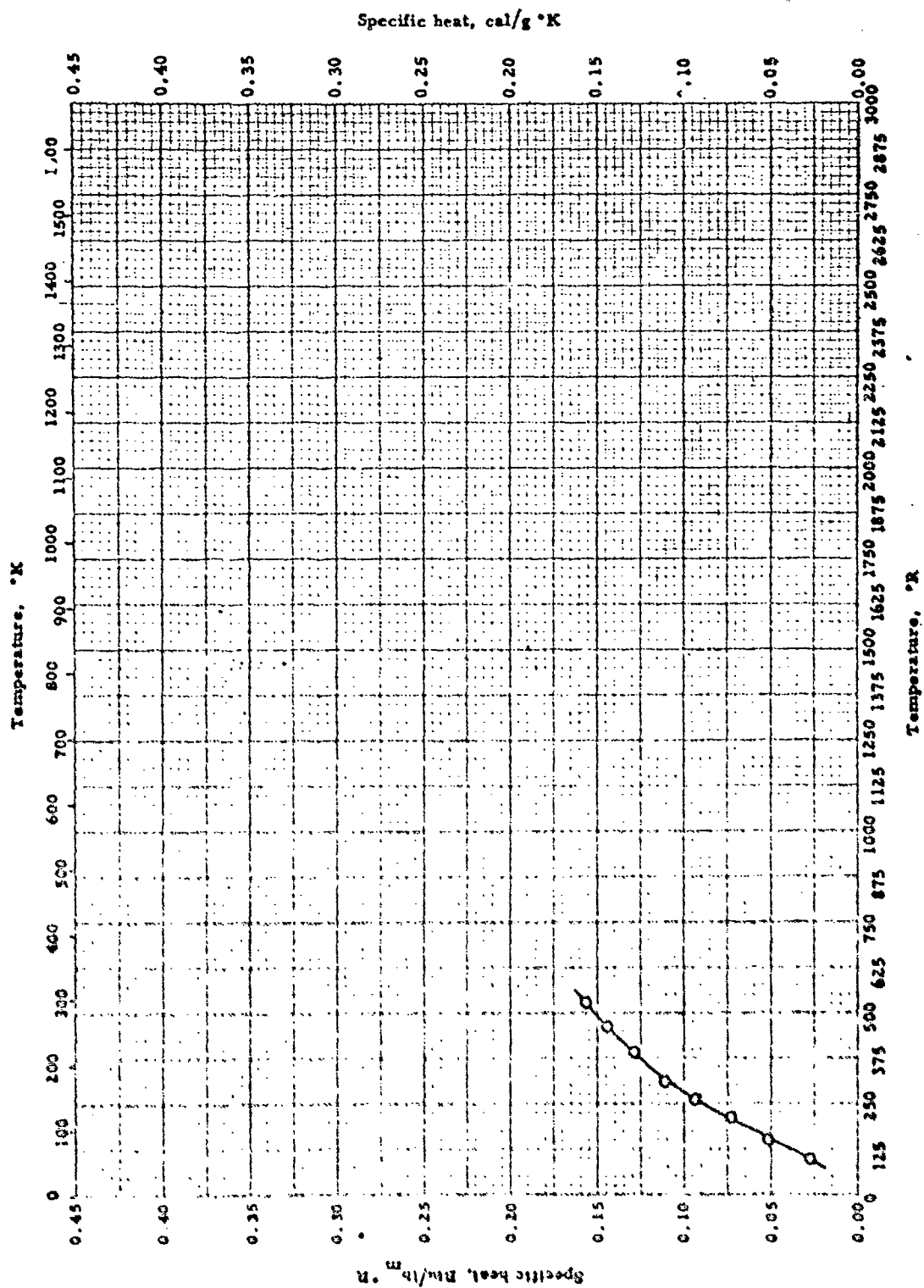
VII - B - 2 - e

ELECTRIC RESISTIVITY -- MAGNESIUM SILICATE

ELECTRIC RESISTIVITY -- MAGNESIUM SILICATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Corneloro, J. E. and Hatch, R. A.	54-93	632-1352	Steatite; grade L-4; AlSiMag 196	High resistance DC bridge	
□	Idid.	54-95	852-1302	Steatite; grade L-5; Pass and Seymour E-211-M	Same as above	
△	Russel Jr., R. and Berberich, L. J.	44-6	672-1172	Commercial steatite; average grade	Potential drop	
◇	Idid.	44-6	932-1661	Commercial ultra-steatite; low loss type	Same as above	
▽	Hatch, W. E.	56-75	1032-1392	Steatite	Resistance bridge. Temp. measured by thermocouple	
○	Idid.	56-75	1012-1392	Forsterite, Magnesium silicate	Same as above	



SPECIFIC HEAT -- MANGANOUS SILICATE

SPECIFIC HEAT -- MANGANOUS SILICATE

REFERENCE INFORMATION

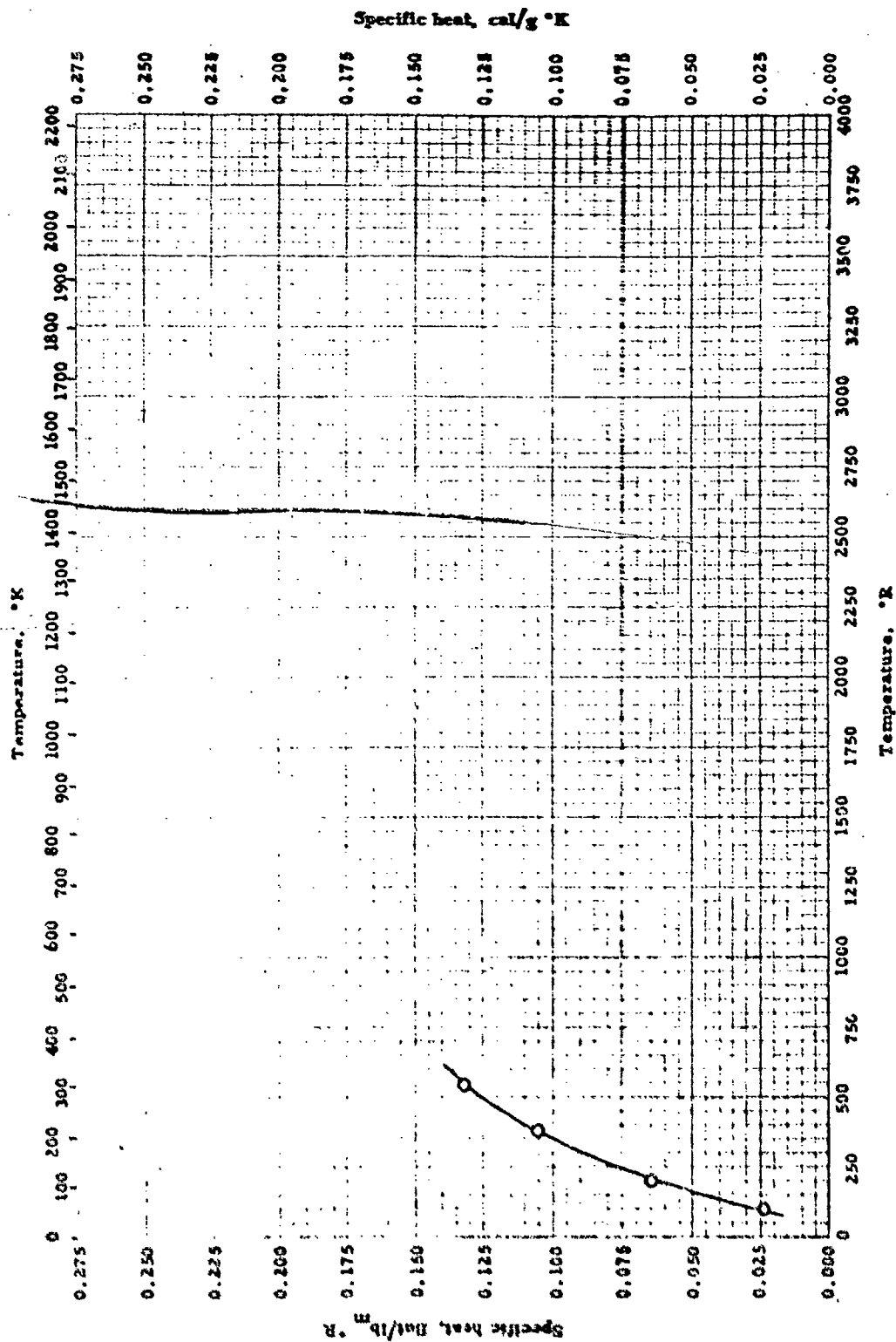
Sym bol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Kelley, K. K.	41-15	95-531	54.16% MnO (cf. theor. 54.15%); p = 230 lb _m /ft ³	Guarded sample	

59-383

WADC TR 58-476

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VII - B - 2 - J



SPECIFIC HEAT -- ZINC SILICATE

SPECIFIC HEAT -- ZINC SILICATE

REFERENCE INFORMATION

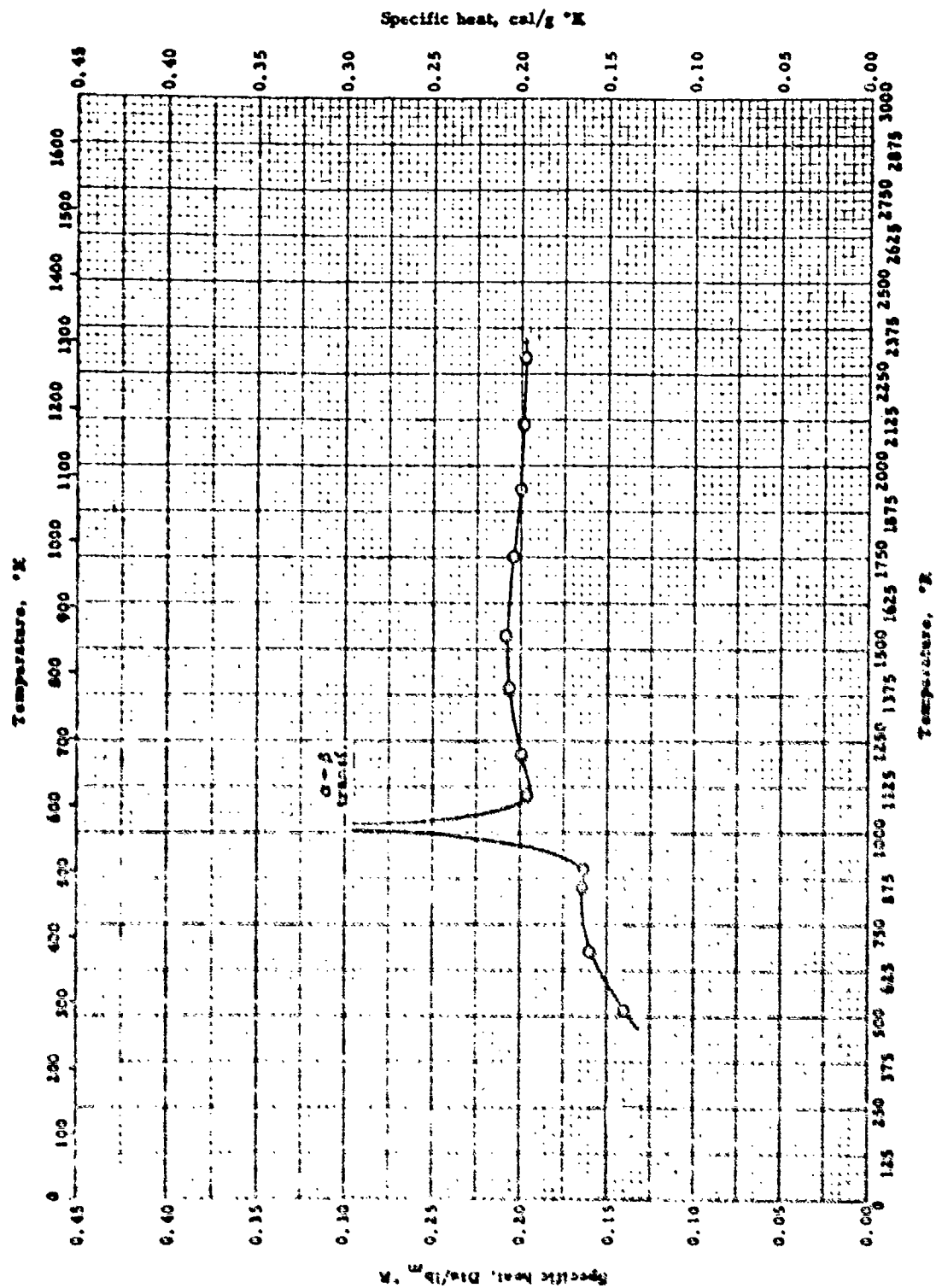
Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Todd, S. S.	51-30	96-536	Zinc Orthosilicate, $ZnSiO_4$ Willemite; 72.95% ZnO (cf. theor. 73.35%); 26.92% SiO_2 (cf. theor. 26.95%); remainder impurities, probably Fe_2O_3 , Al_2O_3 , MgO	Guarded sample	

D 59-479

WADC TR 58-476

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VII - B - 3 - a



SPECIFIC HEAT -- BARIUM FELDSPAR

SPECIFIC HEAT -- BARIUM FELDSPAR

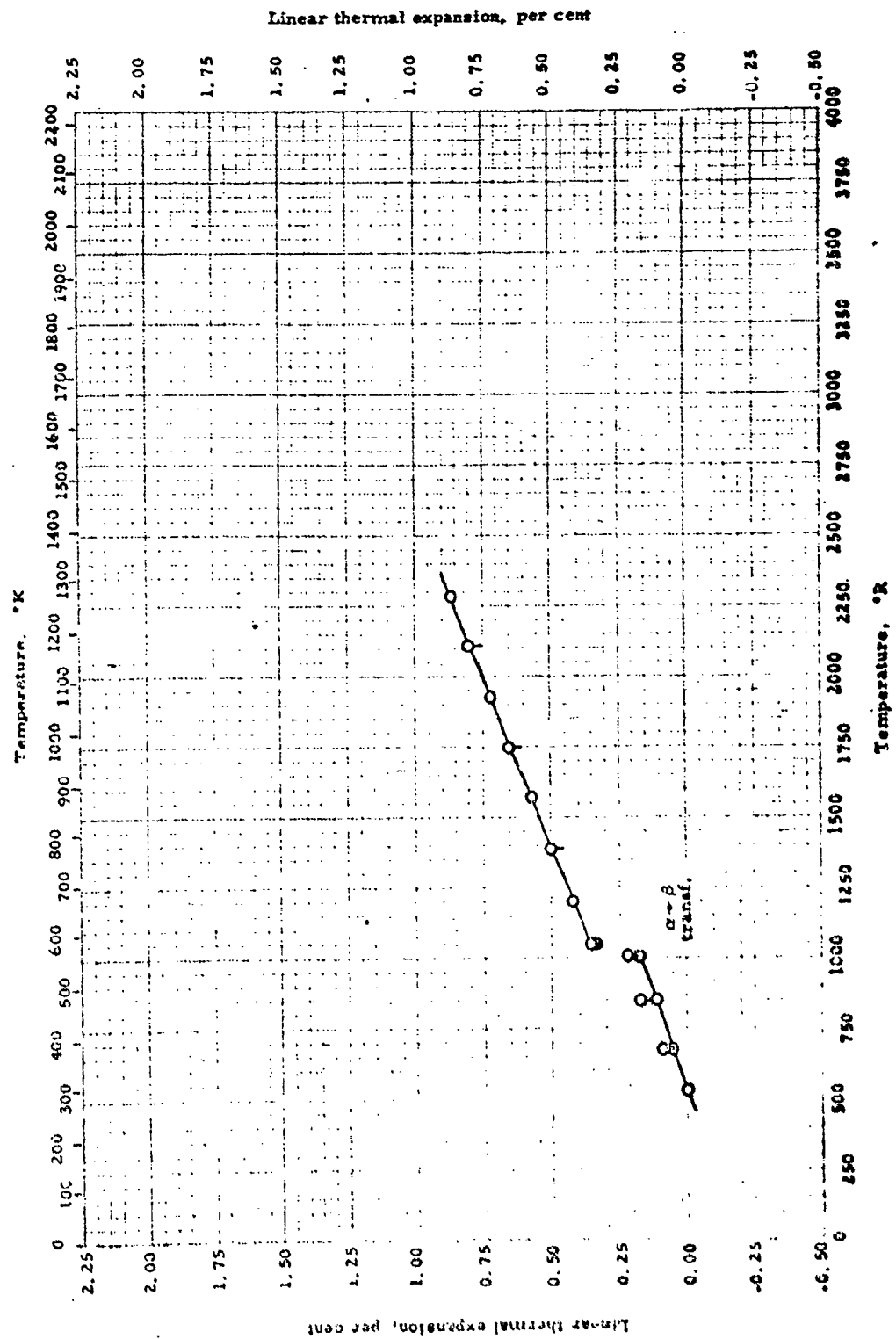
REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
51-14	Yoshida, B. and Matsumoto, K.	51-14	310-1191	41.94% BaO, 29.84% SiO ₂ , 21.67 Al ₂ O ₃ , 1.11% CaO, 0.94% Fe ₂ O ₃ p = 254 lb _m /ft ³ ; prepared from BaCO ₃ and kaolin. Nominal: BaO · Al ₂ O ₃ · 2SiO ₂	Not given	Mixed, kneaded, dried, precalcined at 800°C, electric arc melted, furnace cooled

59-490

WADC TR 58-476

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LINEAR THERMAL EXPANSION -- BARIUM FELDSPAR

VII - B - 3 - A

LINEAR THERMAL EXPANSION -- BARIUM FELDSPAR

REFERENCE INFORMATION

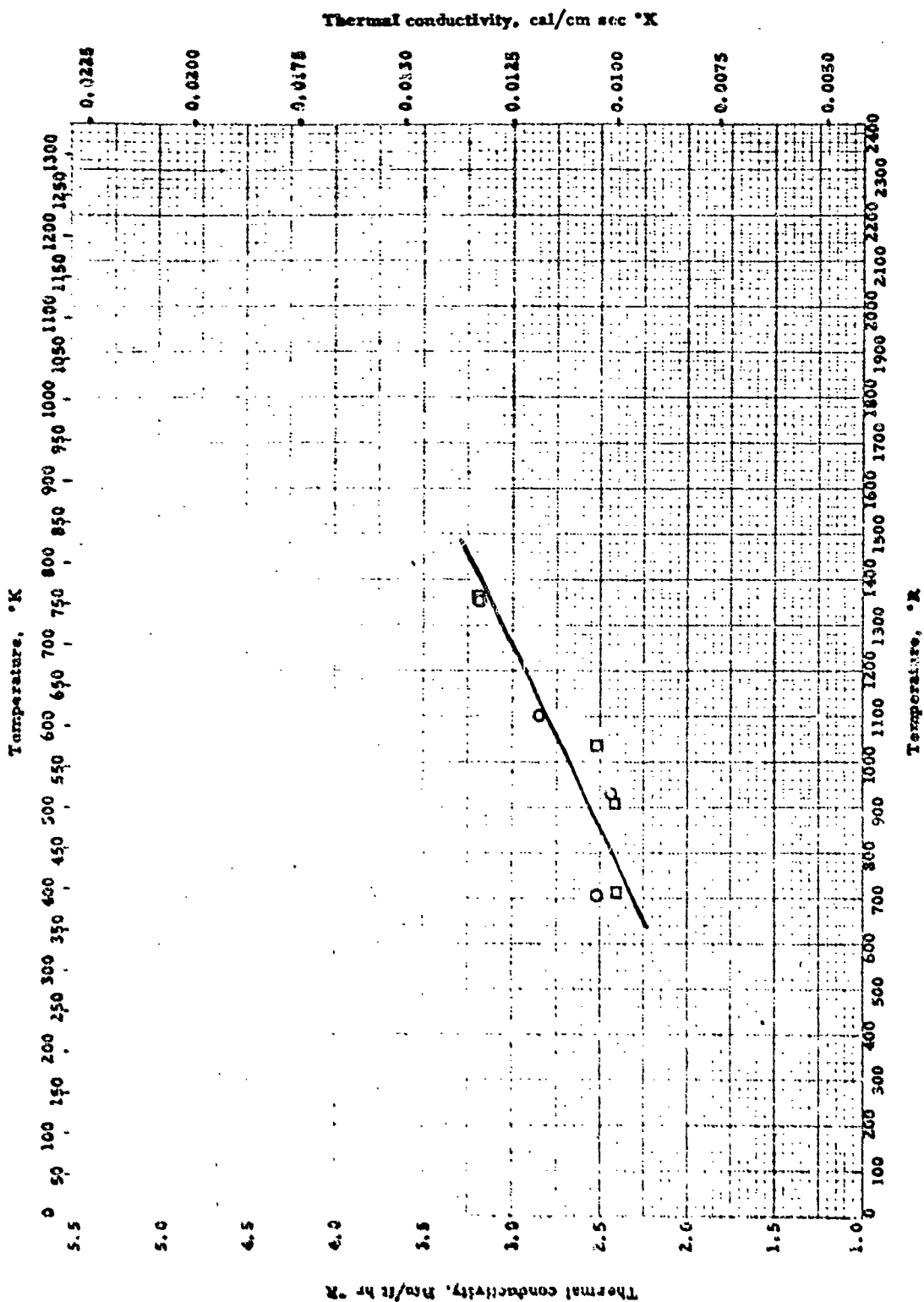
Sym Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Yoshiki, B. and Matsumoto, K.	51-24	528-2292	41.96% BaO; 29.86% SiO ₂ ; 25.67% Al ₂ O ₃ ; 1.53% CaO; 0.94% Fe ₂ O ₃ ; trace of MgO; $\rho = 206.2 \text{ lb/in}^3$	Dilatometer	Synthesized from pure barium carbonate and Kaolin, mixed, kneaded, dried, precalcined at 800°C, melted in electric arc furnace, furnace cooled Q : heating Q : cooling

60-627

WADC TR 54-476

495

VII - B - 3 - b

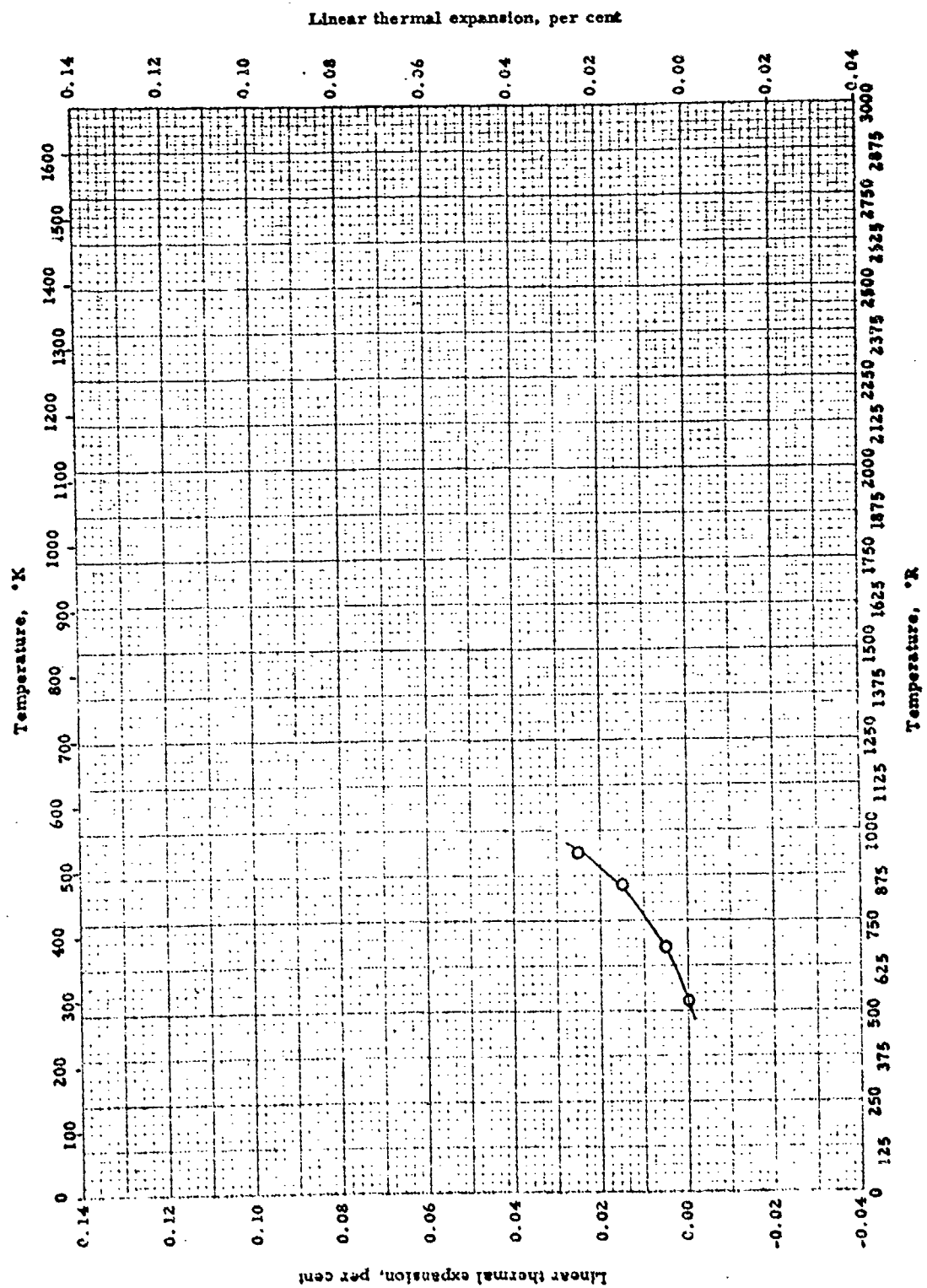


Thermal conductivity -- BERYLLIUM ALUMINOSILICATE

THERMAL CONDUCTIVITY -- BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Knapp, W. J.	3-11	708-1358	Beryl (Brazil), $3\text{BeC} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$	Comparative, rods, Temp. by Chromel-Constantan thermocouple	Meas. parallel to c axis
□	Ibid.	45-11	719-1361	Same as above	Same as above	Meas. normal to c axis

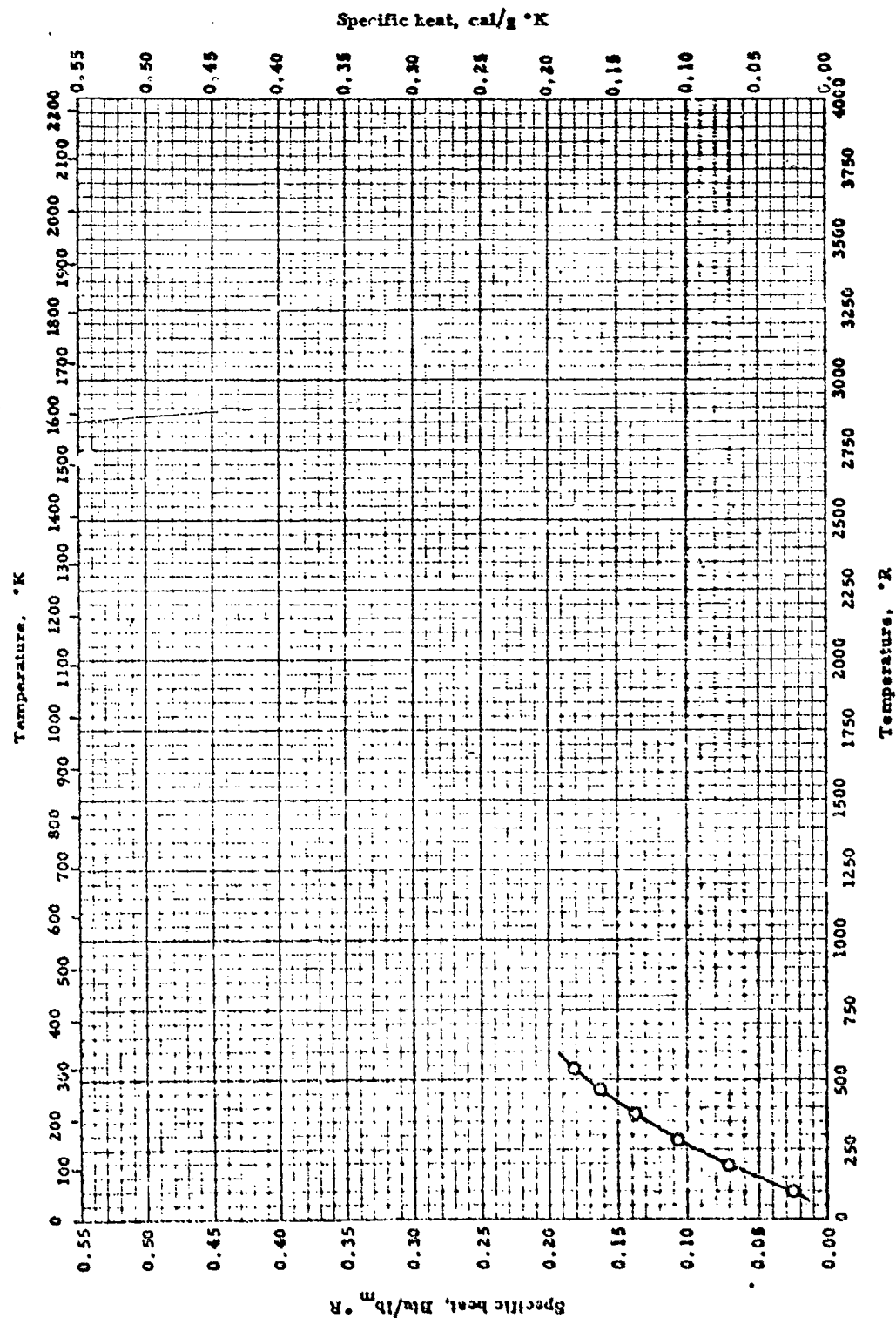


LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Harman, C. G.	52-31	528-942	Beryl	Interferometer	Meas. parallel to c-axis

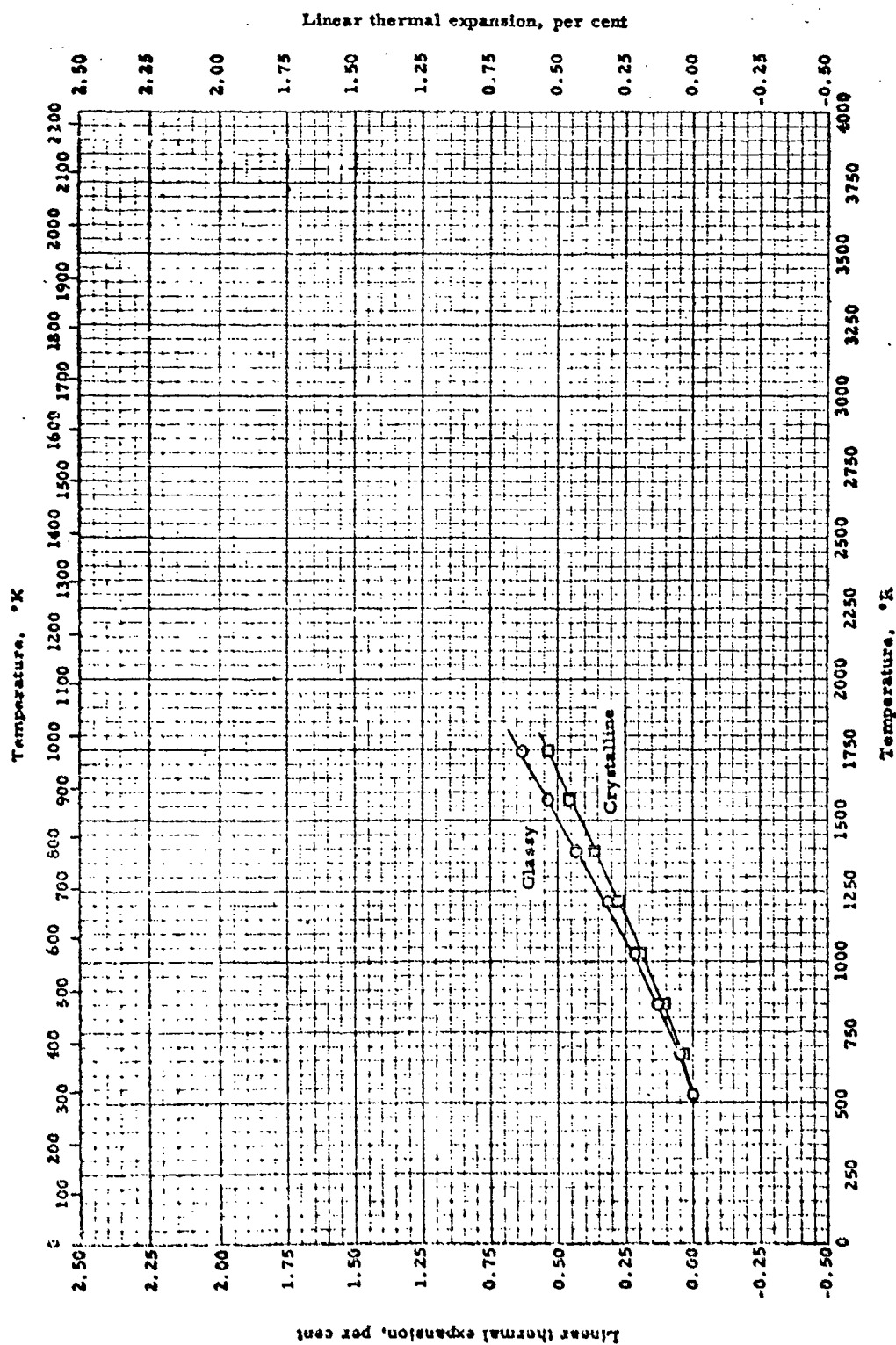


SPECIFIC HEAT -- CALCIUM FELDSPAR

SPECIFIC HEAT -- CALCIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	King, E. G.	57-44	90-536	43.02% SiO_2 ; 36.64% Al_2O_3 ; 20.10% CaO; 0.20% Fe_2O_3	Guarded sample	

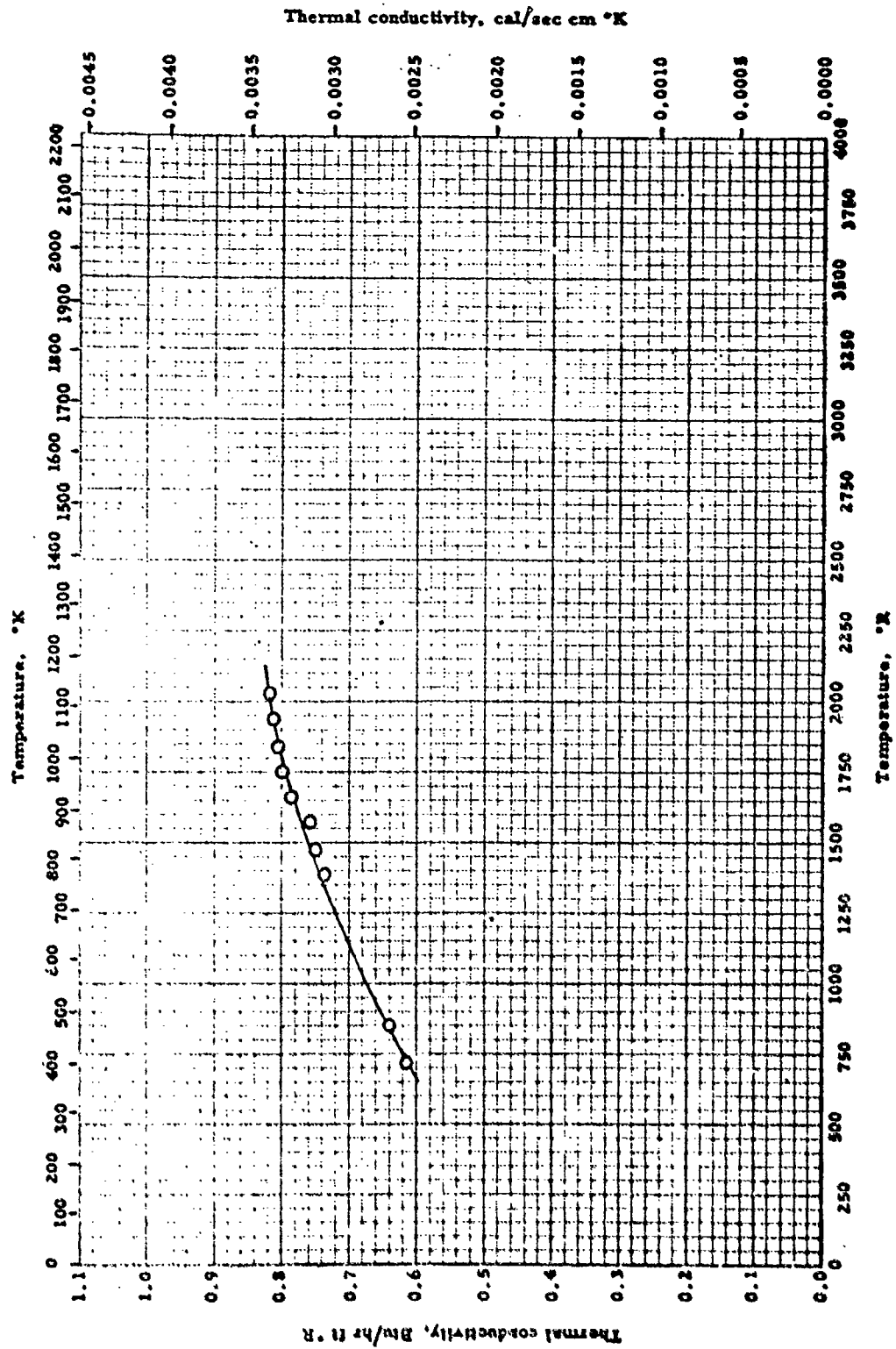


LINEAR THERMAL EXPANSION -- CALCIUM FELDSPAR

LINEAR THERMAL EXPANSION -- CALCIUM FELDSPAR

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	Orlowski, H. J., and Koenig, C. J.	41-10	528-1752	50.68% SiO ₂ ; 30.67% Al ₂ O ₃ ; 13.79% CaO; 3.4% Na ₂ O; 0.50% Fe ₂ O ₃ ; 0.42% MgO; 0.09% K ₂ O; 0.07% TiO ₂ ; glassy state	Interferometer	Annealed 1 hr. at 10°C be- low softening point, cooled in 15 hr.
□	Ibid.	41-10	528-1752	Same as above; crystalline state	Fused quartz dilatometer	Extruded rod plasticized with small amount of gum, air dried, oven dried at 230°F, fired at cone 06

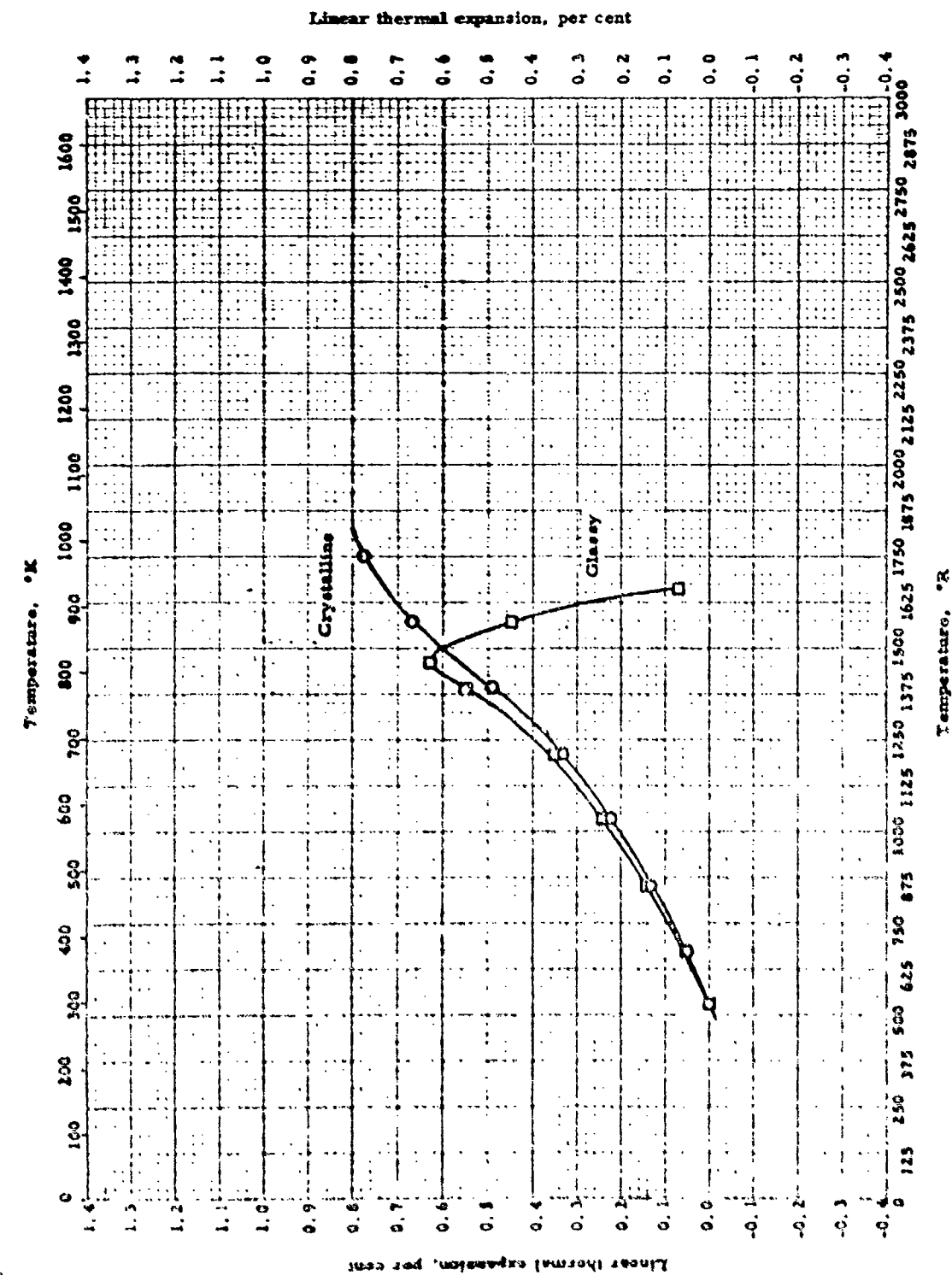


Thermal conductivity -- LITHIUM FELDSPAR

THERMAL CONDUCTIVITY -- LITHIUM FELDSPAR

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Euessem, W. R. and Eush, E. A.	55-10	717-2022	p-Spodumene, 57.8% pottery flint; 24.5% Al ₂ O ₃ ; 17.7% Li ₂ CO ₃	Radial heat flow in cylinder	Fired 5 hr. at 1345°C

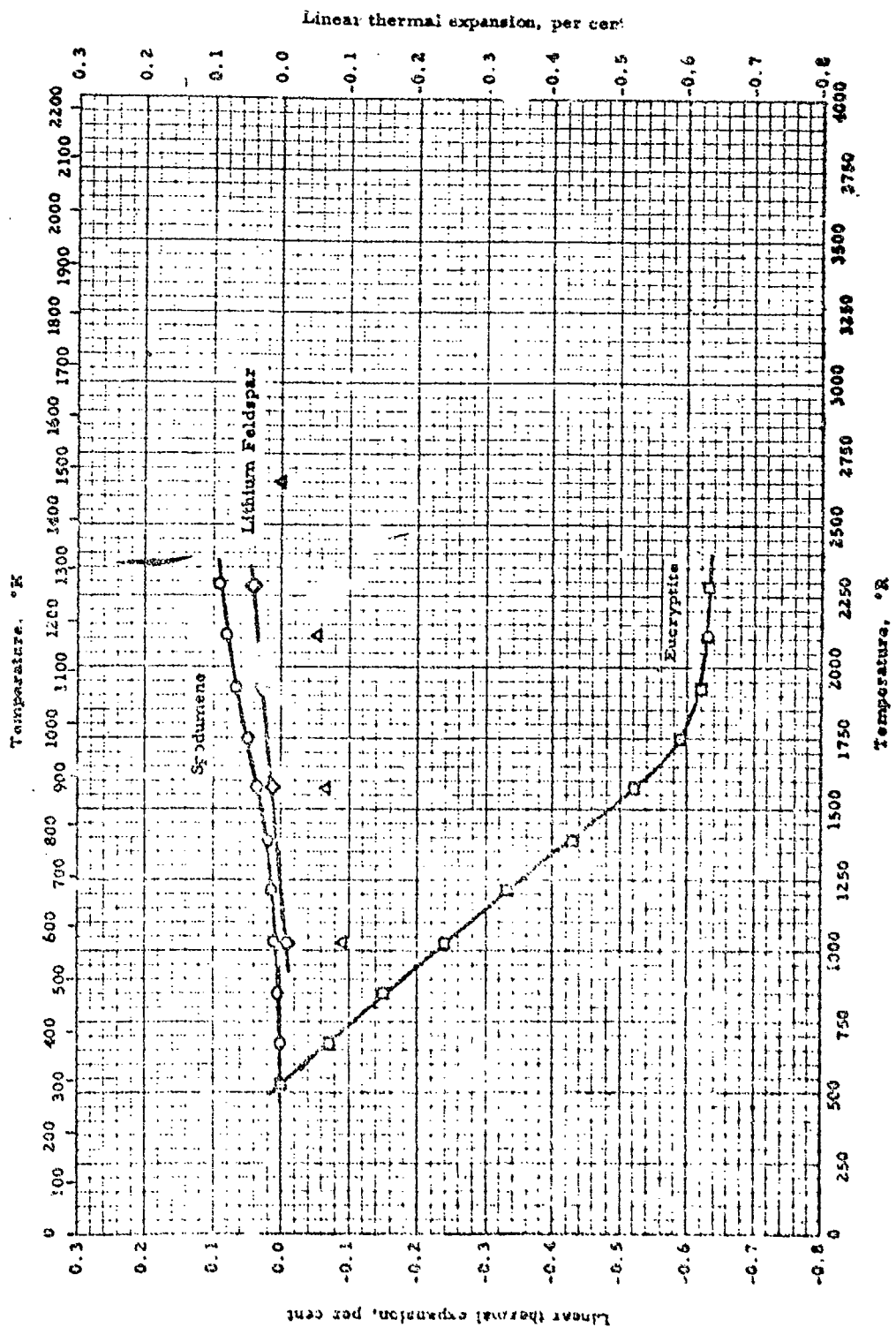


LINEAR THERMAL EXPANSION -- LITHIUM POTASSIUM FELDSPAR

LINEAR THERMAL EXPANSION -- LITHIUM POTASSIUM FELDSPAR

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Tawala, H. J., and Sawyer, C. J.	41-10	528-1462	52.8% SiO ₂ ; 26.71% Al ₂ O ₃ ; 10.33% K ₂ O; 4.65% Li ₂ O; 3.68% F; 0.92% CaO; 0.59% MnO; 0.31% MgO; 0.19% Fe ₂ O ₃ ; 0.13% Na ₂ O; crystalline state	Quartz tube dilatometer	Extruded rod plasticized with small amount of gum, air dried, oven dried at 230° F., and fired at cone 06
Q	Ref. 4.	41-10	528-1752	Same as above; glassy state	Interferometer	Annealed 1 hr. at 10°C below softening point

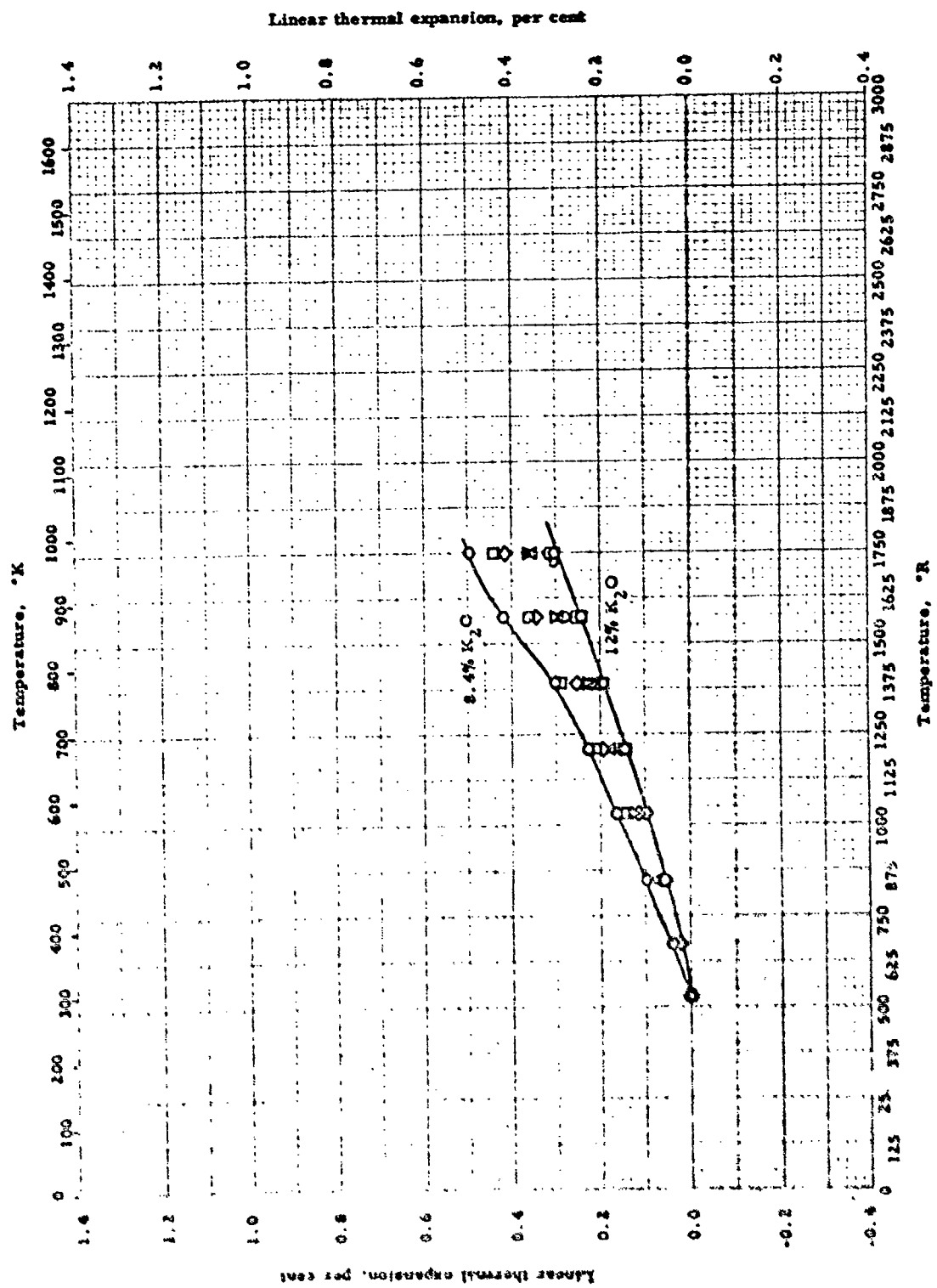


LINEAR THERMAL EXPANSION -- LITHIUM FELDSPAR

LINEAR THERMAL EXPANSION -- LITHIUM FELDSPAR

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Temp., °F.	Material Composition	Test Method	Remarks
○	Hammett, F. A.	51-21	528-2292	Spodumene; 64.6% SiO ₂ ; 27.4% Al ₂ O ₃ ; 8.0% Li ₂ O; prepared from c.p. Li ₂ CO ₃ ; c.p. Al ₂ O ₃ ; potter's flint	Dilatometer	(Li ₂ O · Al ₂ O ₃ · 4SiO ₂) 100 mesh calcined material pressed at 1000 lb/in ² with Carbowax Methocel binder
□	Ibid.	51-21	528-2292	Enclite; 47.7% SiO ₂ ; 40.5% Al ₂ O ₃ ; 11.8% Li ₂ O; raw materials same as above	Same as above	(Li ₂ O · Al ₂ O ₃ · 2SiO ₂) Prepared as above
△	Whittemore, O. J. and Ault, W. N.	56-7	1032-1652	Fine grain	Telemicroscopes sighting on pointed ends of sample	Probably spodumene
◇	Hammett, F. A.	51-21	528-2292	Lithium Feldspar (Li ₂ O · Al ₂ O ₃ · 6SiO ₂), Nominal: 73.2% SiO ₂ ; 20.7% Al ₂ O ₃ ; 5.1% Li ₂ O; prepared from c.p. Li ₂ CO ₃ , Al ₂ O ₃ , and potter's flint	Dilatometer	100-mesh calcined material pressed at 1000 psi using Carbowax Methocel binder

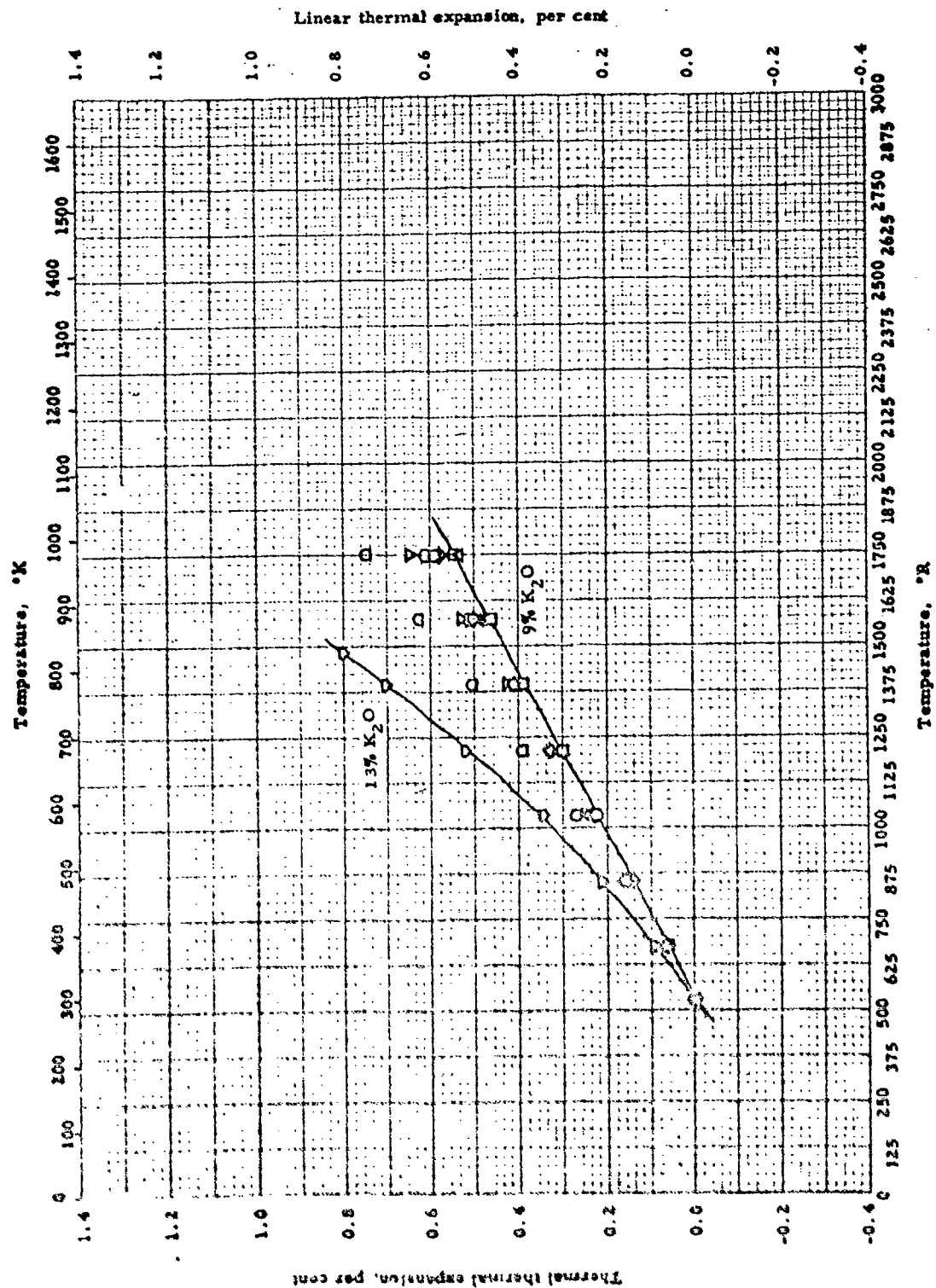


LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ANISOTROPIC (CRYSTALLINE)

LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ANISOTROPIC (CRYSTALLINE)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Orlovskii, N. I. and Zvonig, C. I.	QI-10	528-1752	72.84% SiO ₂ ; 15.4% Al ₂ O ₃ ; 8.42% K ₂ O; 2.93% Na ₂ O; 0.27% CaO; 0.11% MgO; 0.11% Fe ₂ O ₃ ; 0.04% TiO ₂	Quartz tube dilatometer	Included rods plasticized with small amount of gum, air dried, oven dried at 330°F, and fired at cone 06
Q	Did.	QI-10	528-1752	65.3% SiO ₂ ; 17.90% Al ₂ O ₃ ; 10.14% K ₂ O; 2.87% Na ₂ O; 0.31% CaO; 0.07% Fe ₂ O ₃	Same as above	Same as above
Q	Did.	QI-10	528-1752	66.04% SiO ₂ ; 18.76% Al ₂ O ₃ ; 10.73% K ₂ O; 3.56% Na ₂ O; 0.14% MgO; 0.06% TiO ₂ ; 0.08% Fe ₂ O ₃ ; 0.02% CaO	Same as above	Same as above
Q	Did.	QI-10	528-1752	67.68% SiO ₂ ; 18.87% Al ₂ O ₃ ; 10.74% K ₂ O; 2.76% Na ₂ O; 0.49% CaO; 0.05% Fe ₂ O ₃	Same as above	Same as above
Q	Did.	QI-10	528-1752	64.70% SiO ₂ ; 19.50% Al ₂ O ₃ ; 11.21% K ₂ O; 4.19% Na ₂ O; 0.12% MgO; 0.11% CaO; 0.07% Fe ₂ O ₃ ; trace of TiO ₂	Same as above	Same as above
Q	Did.	QI-10	528-1752	67.8% SiO ₂ ; 17.27% Al ₂ O ₃ ; 11.40% K ₂ O; 2.15% Na ₂ O; 0.42% MgO; 0.06% CaO; 0.07% Fe ₂ O ₃	Same as above	Same as above
Q	Did.	QI-10	528-1752	65.33% SiO ₂ ; 19.27% Al ₂ O ₃ ; 12.36% K ₂ O; 2.67% Na ₂ O; 0.27% CaO; 0.08% Fe ₂ O ₃ ; trace of TiO ₂ ; MgO	Same as above	Same as above
Q	Did.	QI-10	528-1752	65.90% SiO ₂ ; 18.70% Al ₂ O ₃ ; 13.00% K ₂ O; 1.70% Na ₂ O; 0.20% CaO; 0.08% Fe ₂ O ₃ ; trace of MgO	Same as above	Same as above



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LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ISOTROPIC (GLASSY)

LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ISOTROPIC (GLASSY)

REFERENCE INFORMATION

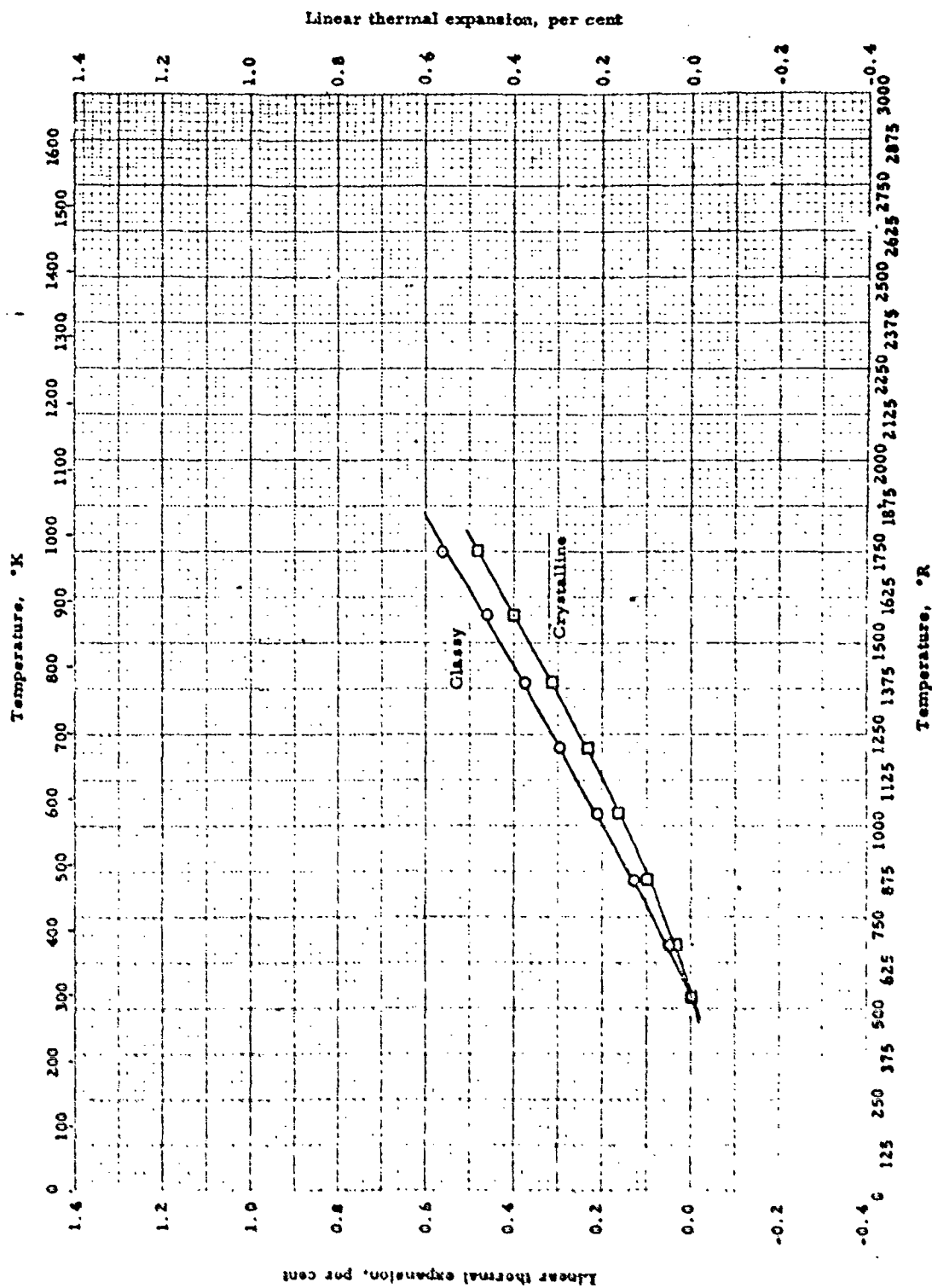
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Grigowski, H. J. and Koenig, C. J.	41-10	528-1752	72.84% SiO ₂ ; 15.4% Al ₂ O ₃ ; 8.42% K ₂ O; 2.93% Na ₂ O; 0.27% CaO; 0.11% MgO; 0.11% Fe ₂ O ₃ ; 0.61% TiO ₂	Interferometer	Annealed 1 hr. at 10°C below softening point and cooled in 15 hr.
□	Idid.	41-10	528-1752	68.10% SiO ₂ ; 17.90% Al ₂ O ₃ ; 10.14% K ₂ O; 2.87% Na ₂ O; 0.31% CaO; 0.07% Fe ₂ O ₃	Same as above	Same as above
△	Idid.	41-10	528-1752	66.04% SiO ₂ ; 18.76% Al ₂ O ₃ ; 10.73% K ₂ O; 3.56% Na ₂ O; 0.14% MgO; 0.09% TiO ₂ ; 0.08% Fe ₂ O ₃ ; 0.62% CaO	Same as above	Same as above
◇	Idid.	41-10	528-1752	67.68% SiO ₂ ; 18.87% Al ₂ O ₃ ; 10.74% K ₂ O; 2.78% Na ₂ O; 0.43% CaO; 0.05% Fe ₂ O ₃	Same as above	Same as above
▽	Idid.	41-10	528-1752	64.70% SiO ₂ ; 19.50% Al ₂ O ₃ ; 11.21% K ₂ O; 4.19% Na ₂ O; 0.12% MgO; 0.11% CaO; 0.07% Fe ₂ O ₃ ; trace of TiO ₂	Same as above	Same as above
○	Idid.	41-10	528-1752	67.84% SiO ₂ ; 17.27% Al ₂ O ₃ ; 11.40% K ₂ O; 2.15% Na ₂ O; 0.42% MgO; 0.08% CaO; 0.07% Fe ₂ O ₃	Same as above	Same as above
○	Idid.	41-10	528-1752	65.13% SiO ₂ ; 19.27% Al ₂ O ₃ ; 12.36% K ₂ O; 2.67% Na ₂ O; 0.27% CaO; 0.08% Fe ₂ O ₃ ; trace of TiO ₂ ; MgO	Same as above	Same as above
○	Idid.	41-10	528-1752	65.90% SiO ₂ ; 18.70% Al ₂ O ₃ ; 13.00% K ₂ O; 1.70% Na ₂ O; 0.20% CaO; 0.08% Fe ₂ O ₃ ; trace of MgO	Same as above	Same as above

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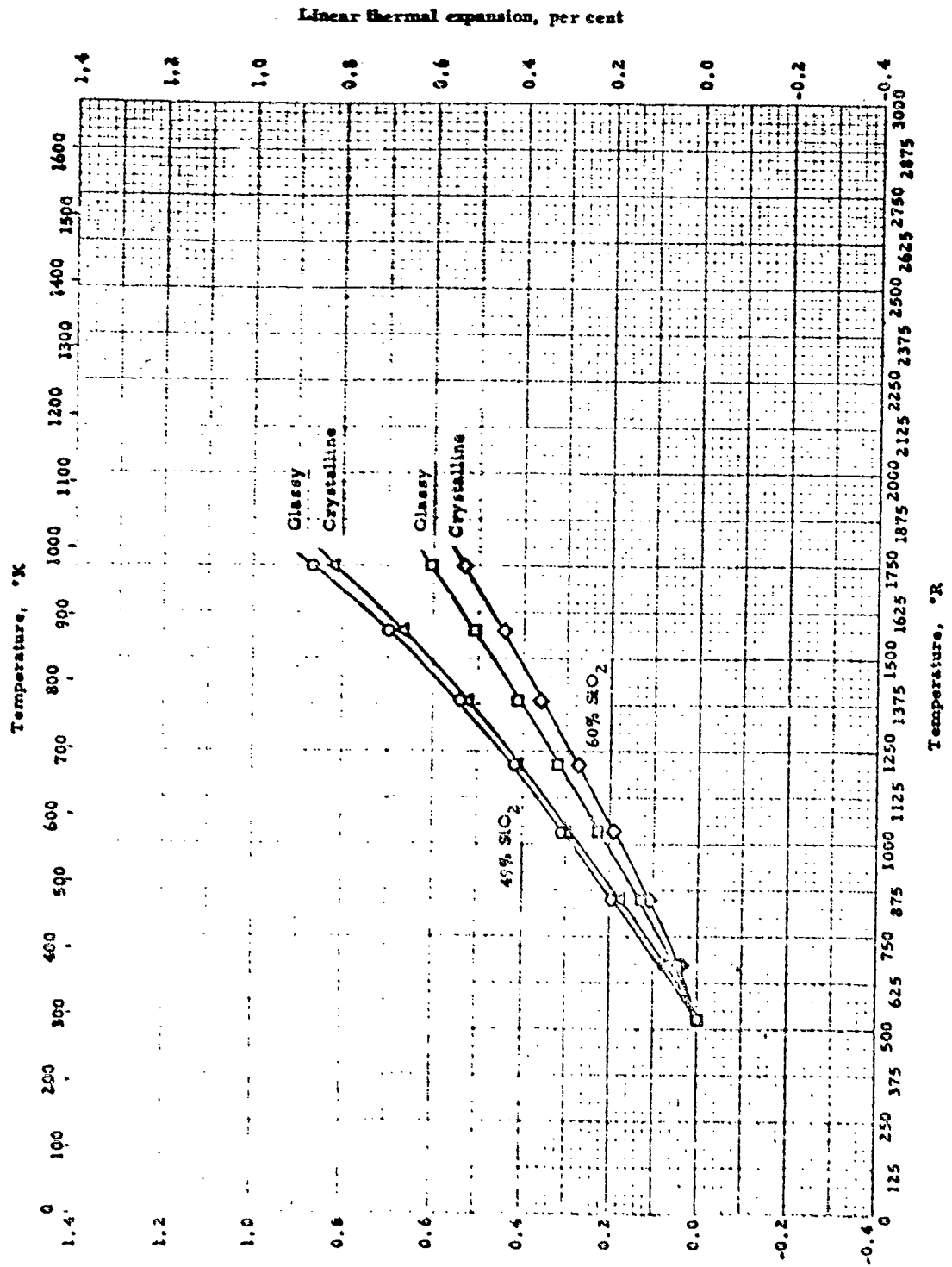


LINEAR THERMAL EXPANSION -- SODIUM-POTASSIUM FELDSPAR

LINEAR THERMAL EXPANSION -- SODIUM-POTASSIUM FELDSPAR

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowski, H. J. and Koenig, C. J.	41-10	528-1752	69.12% SiO ₂ ; 18.04% Al ₂ O ₃ ; 6.70% K ₂ O; 5.18% Na ₂ O; 0.98% CaO; 0.08% Fe ₂ O ₃ ; traces of MgO; iso- tropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10° C below softening point, cooled in 15 hr.
□	Ibid.	41-10	528-1752	Same as above; anisotropic (crystal- line)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06

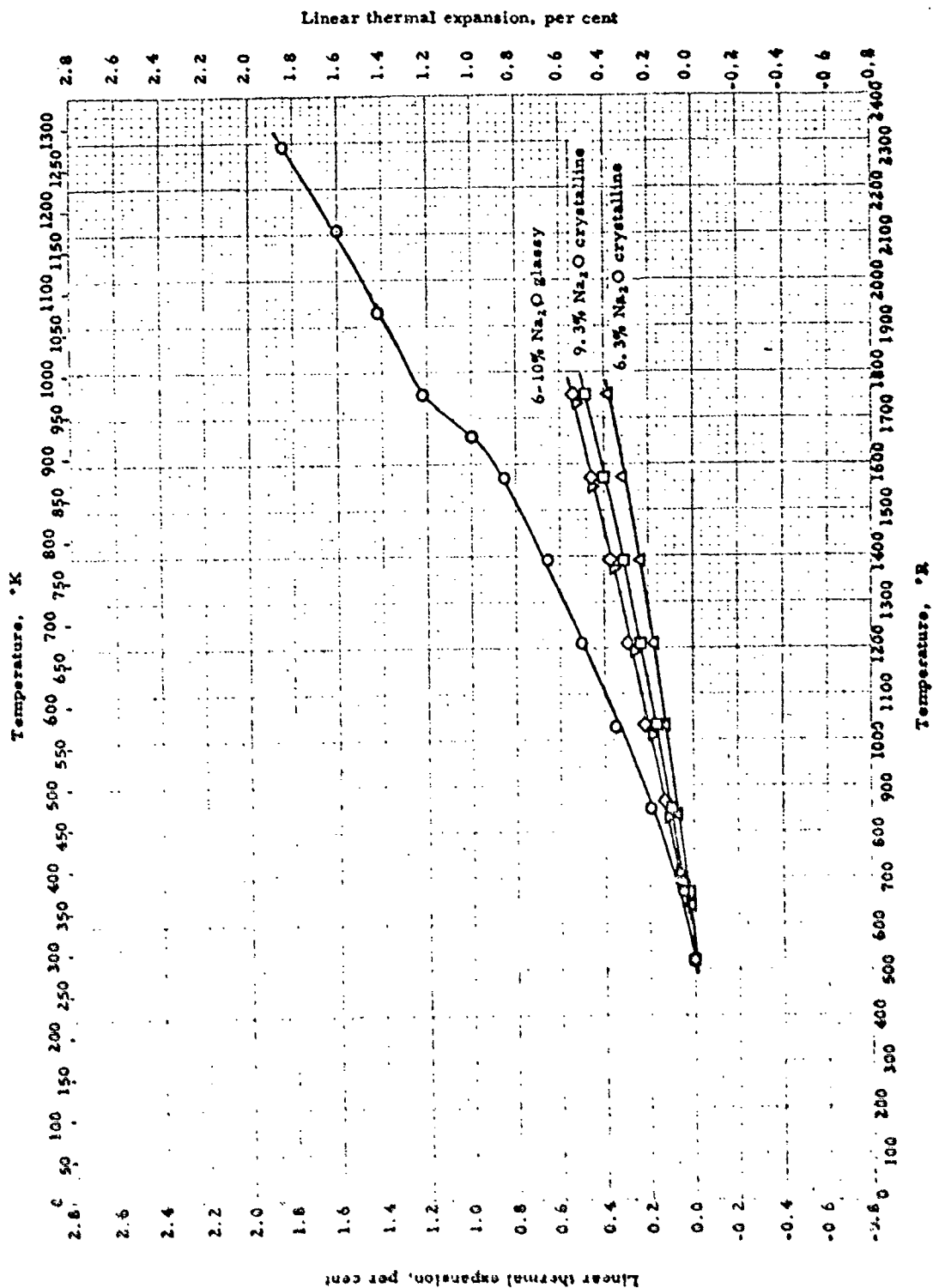


LINEAR THERMAL EXPANSION -- NEPHELINE SYENITE

LINEAR THERMAL EXPANSION -- NEPHELINE SYENITE

REFERENCE INFORMATION

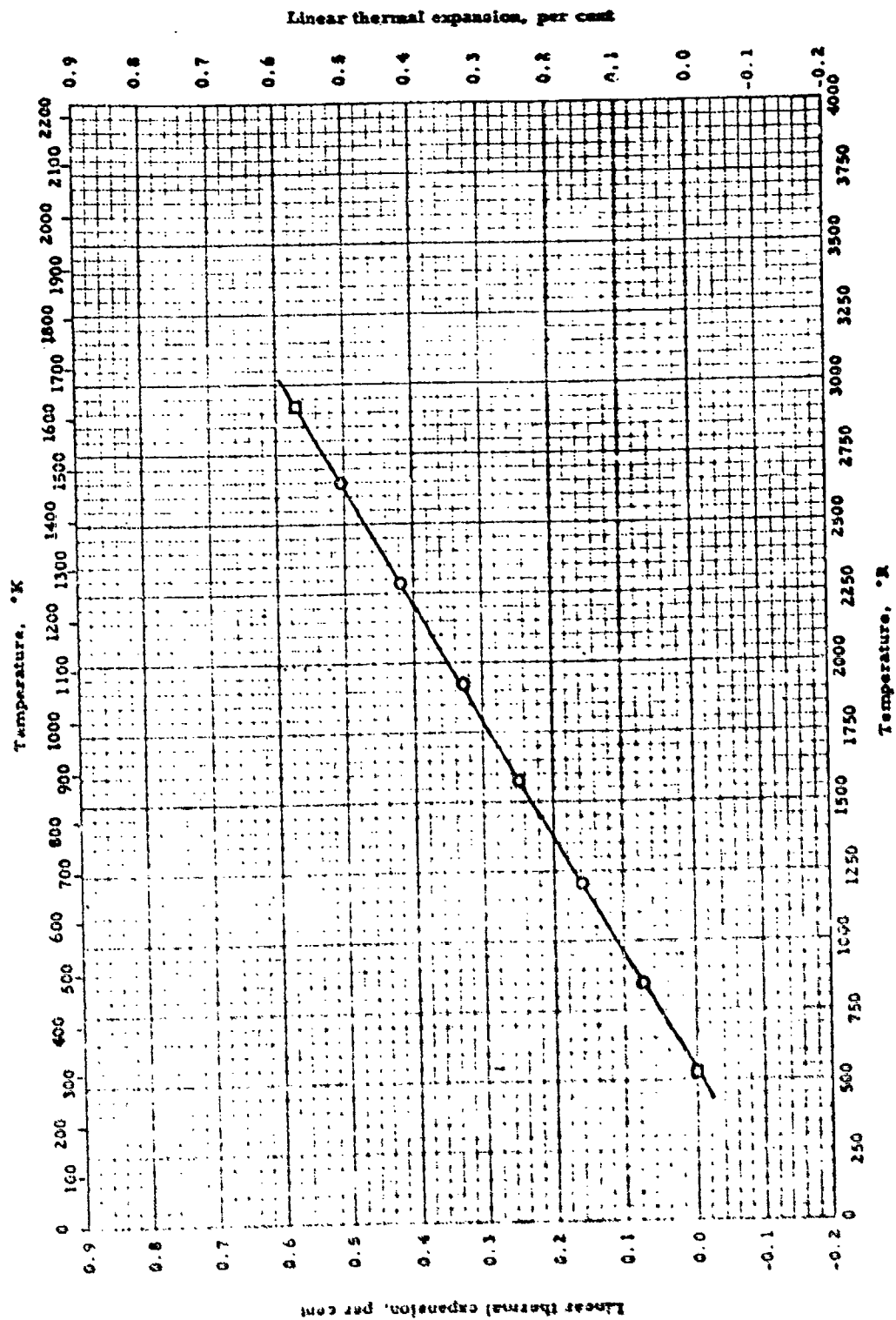
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowitz, H. J., and Koenig, C. J.	41-10	528-1752	48.92% SiO ₂ ; 31.69% Al ₂ O ₃ ; 13.70% Na ₂ O; 4.06% K ₂ O; 0.86% CaO; 0.19% Fe ₂ O ₃ ; 0.06% MgO; 0.01% TiO ₂ ; ign. loss 0.43%; isotropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10°C below the softening point, cooled in 15 hr.
△	Ibid.	41-10	528-1752	Same as above; anisotropic (crystalline)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06
□	Ibid.	41-10	528-1752	60.24% SiO ₂ ; 24.05% Al ₂ O ₃ ; 10.03% Na ₂ O; 5.01% K ₂ O; 0.15% CaO; 0.06% Fe ₂ O ₃ ; 0.02% MgO; 0.002% TiO ₂ ; isotropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10°C below the softening point, cooled in 15 hr.
◇	Ibid.	41-10	528-1752	Same as above; anisotropic (crystalline)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06



LINEAR THERMAL EXPANSION -- SODIUM FELDSPAR

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A.	49-14	528-2492	42.3% SiO ₂ ; 35.9% Al ₂ O ₃ ; 21.8% Na ₂ O; prepared from pottery flint, c.p. Al ₂ O ₃ , c.p. Na ₂ CO ₃	Fused silica dilatometer	Wet milled in acetone, held 50 hrs at 1100°C, 4 hr at 1400°C, pressed and sin- tered 1 hr at 1400°C
□	Orlowski, H.J. and Kownig, C.J.	41-10	528-1752	68.40% SiO ₂ ; 19.40% Al ₂ O ₃ ; 9.30% Na ₂ O; 1.40% K ₂ O; 1.00% CaO; 0.07% Fe ₂ O ₃ ; trace of MgO	Quartz tube dilatometer	Extruded rods plasticized with small amount of gum, air dried, oven dried at 230 °F, and fired at cone 6.5
△	Ibid.	41-10	528-1752	60.64% SiO ₂ ; 23.69% Al ₂ O ₃ ; 6.28% Na ₂ O; 3.27% K ₂ O; 5.14% CaO; 0.25% Fe ₂ O ₃ ; trace of MgO	Same as above	Same as above
◇	Ibid.	41-10	528-1752	68.40% SiO ₂ ; 19.40% Al ₂ O ₃ ; 9.30% Na ₂ O; 1.40% K ₂ O; 1.00% CaO; 0.07% Fe ₂ O ₃ ; trace of MgO	Interferometer	Annealed 1 hr, at 10 °C be- low softening point and cooled in 15 hr.
▽	Ibid.	41-10	528-1752	60.64% SiO ₂ ; 23.69% Al ₂ O ₃ ; 6.28% Na ₂ O; 3.27% K ₂ O; 5.14% CaO; 0.25% Fe ₂ O ₃ ; trace of MgO	Same as above	Same as above



LINEAR THERMAL EXPANSION -- HAFNIUM SILICATE (HAFNON)

LINEAR THERMAL EXPANSION -- HAFNIUM SILICATE (HAFNION)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
54-45 also 54-46	Currie, C. E., Loney, J. M., and Johnson, J. R.	54-45 also 54-46	572-2832	Prepared from 99.5 + % pure HfO_2 and quartz	Sapphire dilatometer	Equimolar 325 mesh powders heated to 1550°C, milled, reheat- ed, pressed at 20,000 lb/in ² , fired 2 hr, at 1880°C
57-23	Wilke, C. F., and Lewis, G.	57-23	520-2922	Prepared from HfO_2 containing 1% excess Hf, 1% Zr, 0.5-1.0% Sn, Fe, Al; 0.1-0.5% Mg; 0.25-0.5% Si, Ti, Ca; 0.005-0.010% Al; 0.001-0.005% Cu, Mn, Co. The SiO_2 contained 1% excess Al; 0.01-0.05% Al; 0.001-0.005% Mg; 0.0001-0.0005% Cu, Ca, Ti	Not given	

PROPERTIES OF ZIRCONIUM SILICATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	290 lb _m /ft ³	4.7 g/cm ³
Melting Point.	5030°R *	2823°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	283	4.54
□	232.8 ± 0.6	3.73 ± 0.01

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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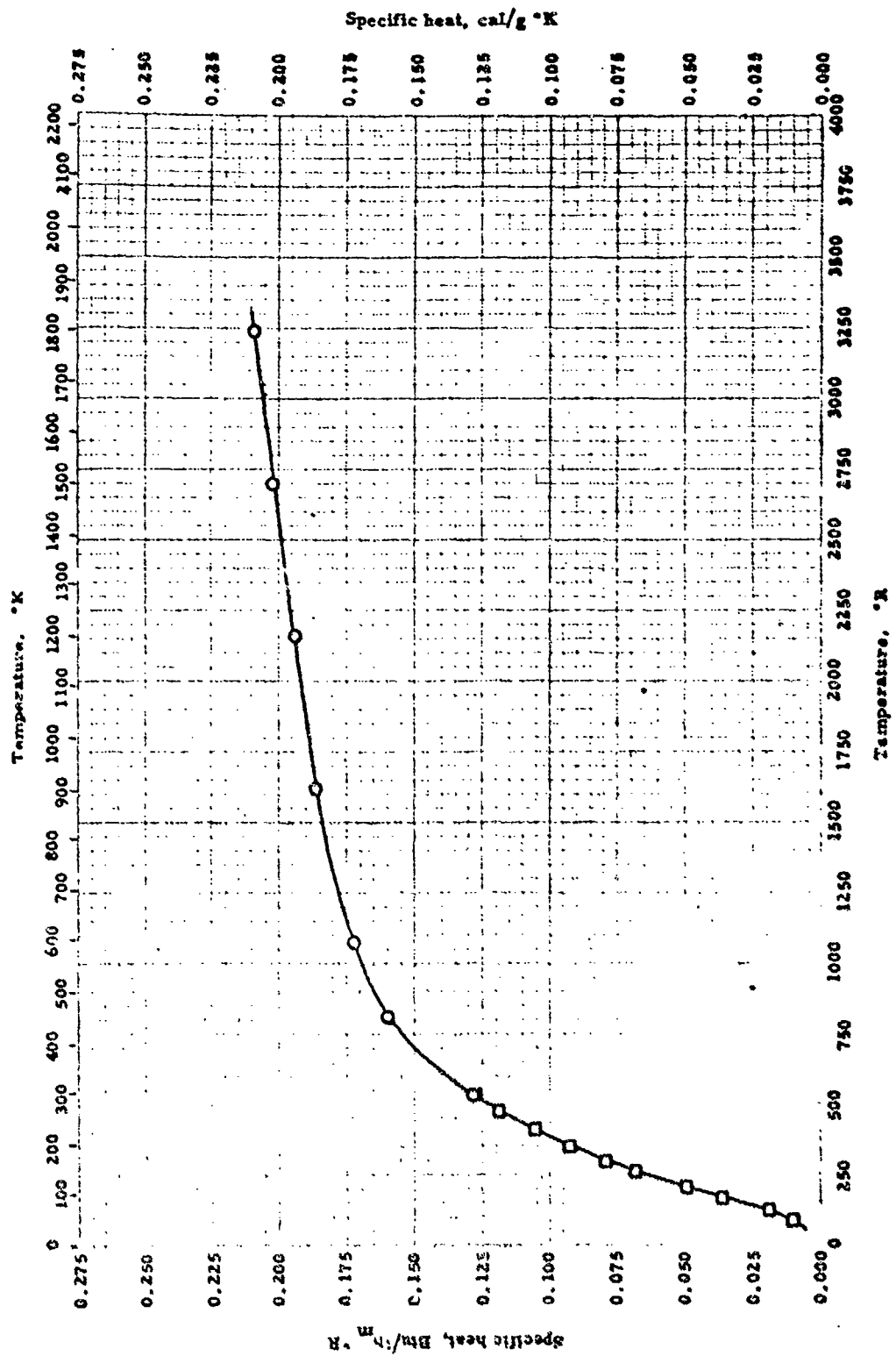
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF ZIRCONIUM SILICATE

REFERENCE INFORMATION

Sym No	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Gangler, J.J.	50-10	Room	49.80% Zr; 33.98% O ₂ ; 15.86% Si; 0.82% combined C; <0.01% free C (Zircon)	p: weight in air and in distilled water	Fabricated by hot pressing in graphite mold. Auth. computes $\rho = 4.72 \text{ g/cm}^3$ from lattice measured by others
Q	Oak Ridge National Lab.	57-150	537	Zircon 475	p: weight in air and in kerosene	Measured by O. Sloman, C. D. Bopp and R. L. Towns



SPECIFIC HEAT -- ZIRCONIUM SILICATE

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SPECIFIC HEAT -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

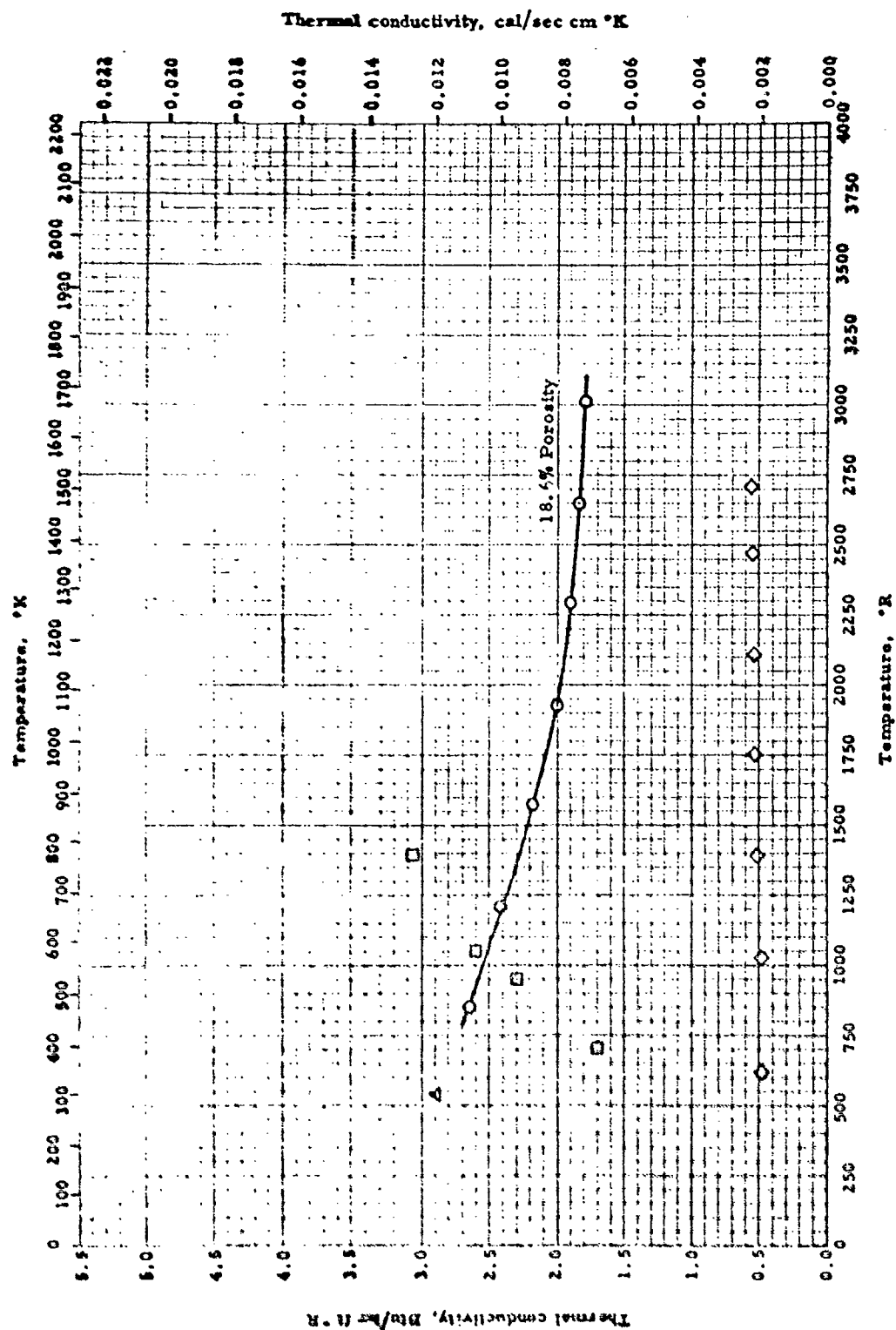
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Coughlin, J. P. and King, E. G.	50-3	693-1281	ZrSiO ₄ , 66.3% ZrO ₂ including H ₂ O ₂ with 1.15% H ₂ ; 33.6% SiO ₂ ; 0.4% Fe ₂ O ₃	Drop method; copper block calorimeter	Corrected for Fe ₂ O ₃ and excess SiO ₂
□	Kelley, K. K.	41-12	95-931	95.6% ZrSiO ₄ ; 1.3% SiO ₂ ; 0.4% Fe ₂ O ₃	Guarded sample	

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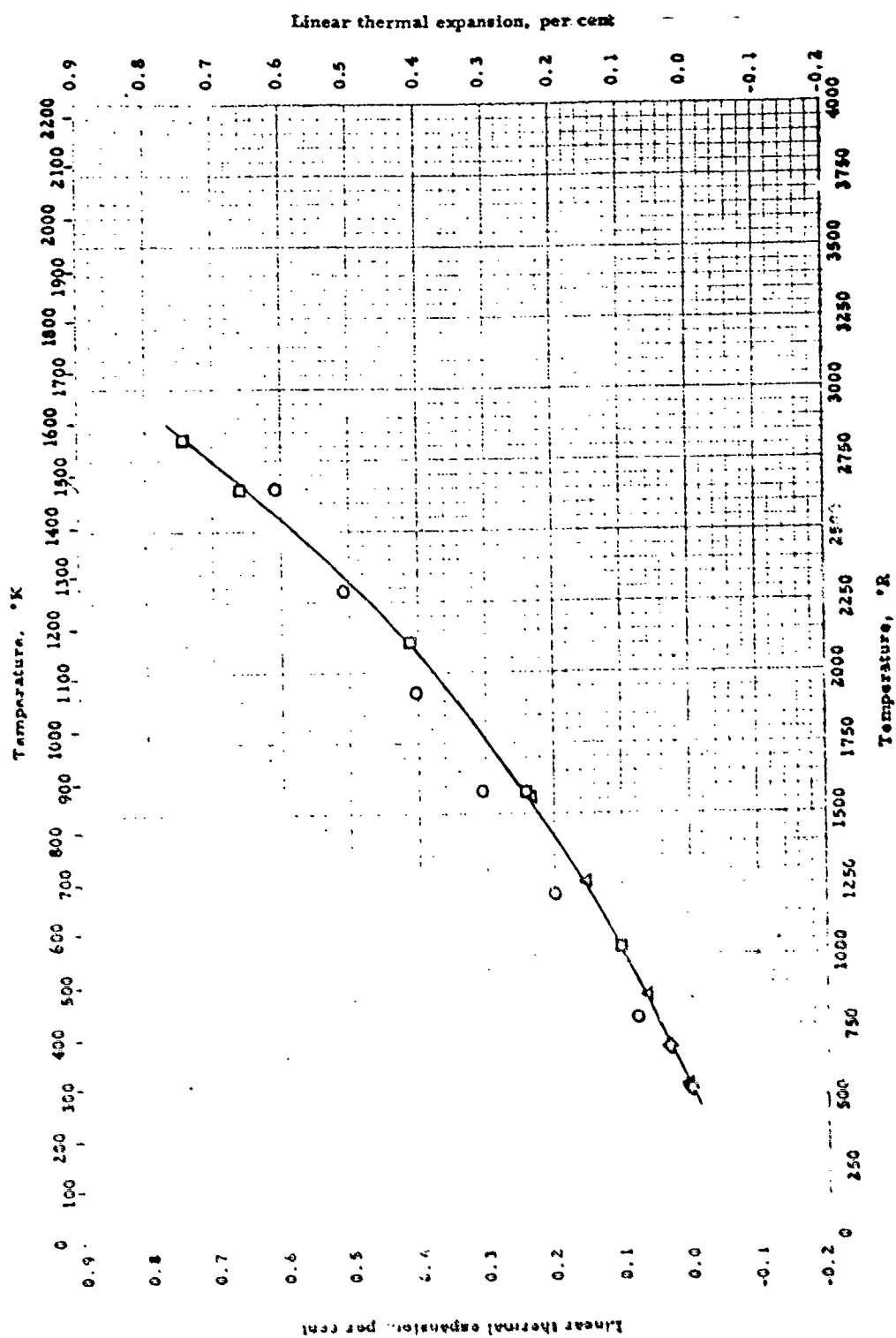


Thermal conductivity -- ZIRCONIUM SILICATE

THERMAL CONDUCTIVITY -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Kingery, W. D. and Francis, J.	52-65 also 53-65 also 54-1	852-3012	Bulk $\rho = 230 \text{ lb}_m/\text{ft}^3$; porosity = 18.6%	Ellipsoidal envelope	Slip cast and fired at 1550°C
□	Knapp, W. J.	43-11	700-1390	Brazil Zircon	Comparative; rods	Single crystal normal to c-axis
△	Oak Ridge National Laboratory	57-150	546	Zircon 475	Not described here; refers to others	Auth. est. accuracy $\pm 8\%$; measured by O. Sisman, C. D. Bopp and R. L. Towns
◇	Norton, F. H. and Kingery, W. D.	51-75	670-2710	"Pure" Zircon, porosity = 2%	Ellipsoidal envelope with resistance heater; temp. by thermocouple	Suprapax Zircon of Natl. Lead Co. treated with HCl, fired at 1550°C, zero open pores; auth. est. accuracy $\pm 8\%$



LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE

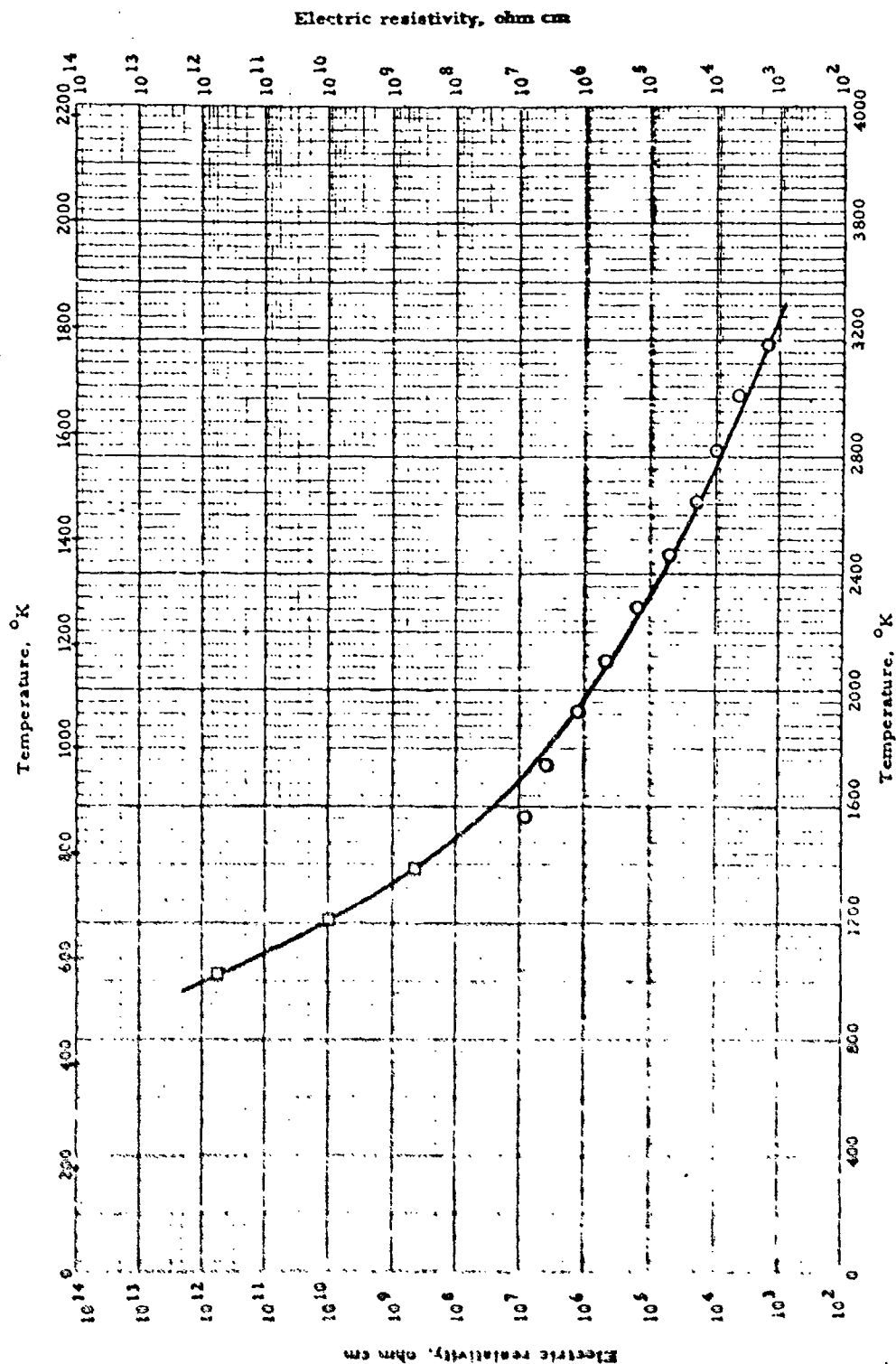
LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. R., Donay, L. N., and Johnson, J. R.	54-45 also 54-46	528-2832	Prepared from 99.9% pure ZrO_2 and quartz	Sapphire dilatometer	Equimolar 325 mesh powders heated to 1550°C, milled, heated again; pressed at 20,000 lb/in. ² ; fired 2 hr at 1550°C
□	Whittemore, O. J. and Allen, N. N.	56-7	1032-2832	Fine grain zircon, $ZrSO_4$	Telemicroscopes sighting on pointed ends of rods	
△	Gangler, J. J.	50-10	540-1550	48.80% Zr, 33.95% O_2 ; 15.86% Si; 0.82% combined C; < 0.01% free C. $p = 283$ lb./ft. ²	Interferometer	Hot pressed in graphite mold tested at 4° C/min rise
○	McKee, J. H. and Adams, A. M.	50-11	528-672	66.45% total $ZrO_2 + H_2O$; 32.45% SiO_2 ; 0.99% total Al_2O_3 ; rare earth oxides; 0.29% FeO ; 0.15% TiO_2 ; 0.08% Mn_2O_4 ; trace BaO ; no CaO or MgO	Not given	Fired at 1750°C

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ELECTRIC RESISTIVITY -- ZIRCONIUM SILICATE

ELECTRIC RESISTIVITY -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

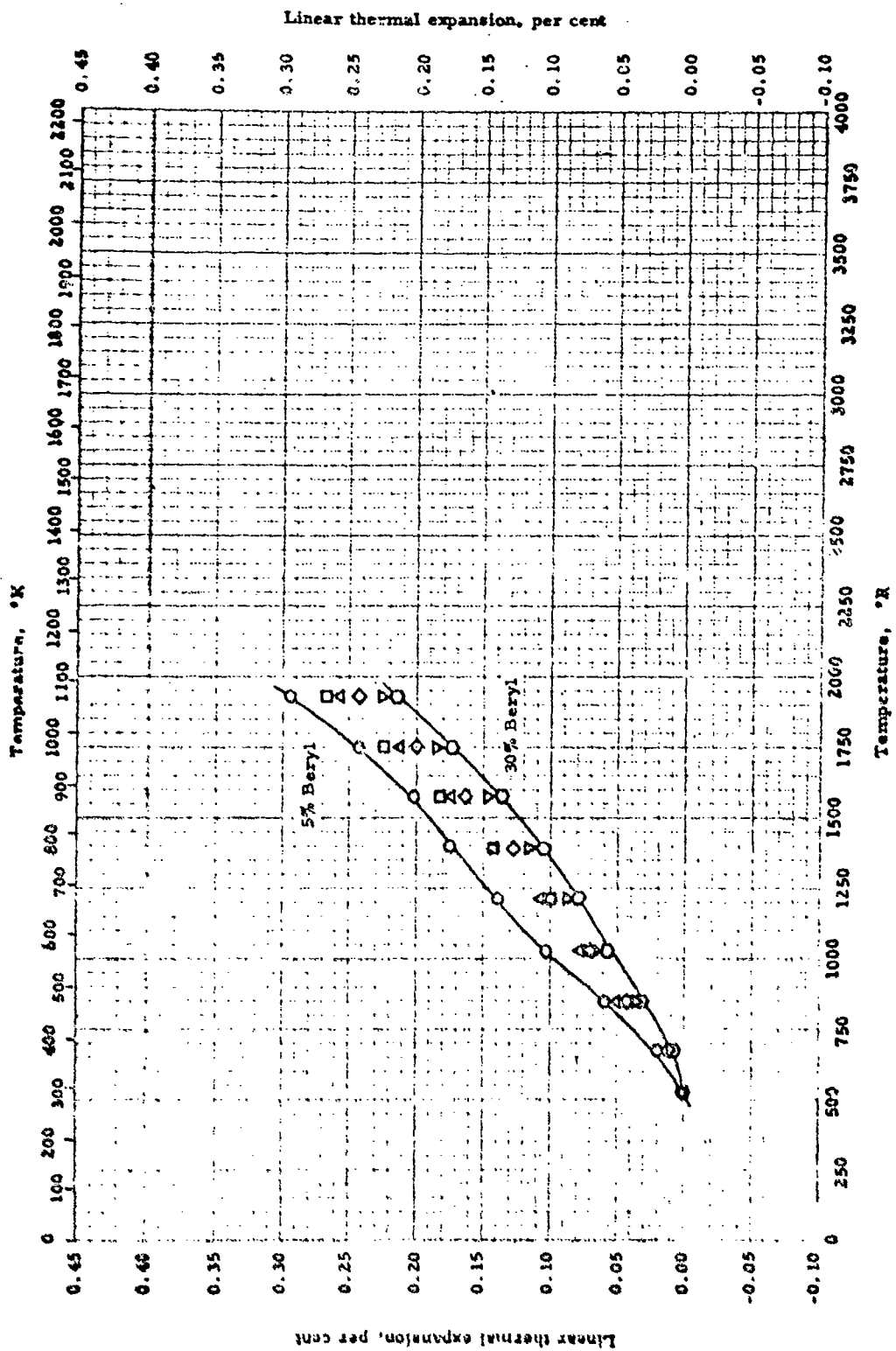
No.	Investigator	Z.L.	Range, °F.	Material Composition	Test Method	Remarks
O	Chloebath, V.E. and Henry, E.C.	53-94	1572-3192	Zircon. 65% ZrO_2 ; 35% SiO_2	Wheatstone bridge at 965 cycles	Apparent Porosity 10%, > 42 pyrometric cone equivalent
□	Hauth, W.E.	56-75	1032-1992	Zircon	Bridge method, temp. by thermocouple	

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LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE + BERYLLIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE + BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Sym- bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Thermal, F. A. and Henry, E. C.	46-5	528-1932	95% ZrSiO ₄ ; 5% BeO·Al ₂ O ₃ ·6SiO ₂ (zircon + beryl system)	Quartz dilatometer	
□	Ibid.	46-5	528-1932	90% ZrSiO ₄ ; 10% BeO·Al ₂ O ₃ ·6SiO ₂	Same as above	
△	Ibid.	46-5	528-1932	85% ZrSiO ₄ ; 15% BeO·Al ₂ O ₃ ·6SiO ₂	Same as above	
◇	Ibid.	46-5	528-1932	80% ZrSiO ₄ ; 20% BeO·Al ₂ O ₃ ·6SiO ₂	Same as above	
▽	Ibid.	46-5	528-1932	75% ZrSiO ₄ ; 25% BeO·Al ₂ O ₃ ·6SiO ₂	Same as above	
○	Ibid.	46-5	528-1932	70% ZrSiO ₄ ; 30% BeO·Al ₂ O ₃ ·6SiO ₂	Same as above	

Symbol	Nominal Composition	Melting Point		Heat of Fusion	
		° R	° K	Btu/lb _m	cal/g
O	3 CaO · B ₂ O ₃	3168	1760	269	149
	2 CaO · B ₂ O ₃	2855	1585	239	133
	CaO · B ₂ O ₃	2583	1435	253	141
	CaO · 2 B ₂ O ₃	2268	1260	249	139

PROPERTIES OF CALCIUM BORATE

PROPERTIES OF CALCIUM BORATE

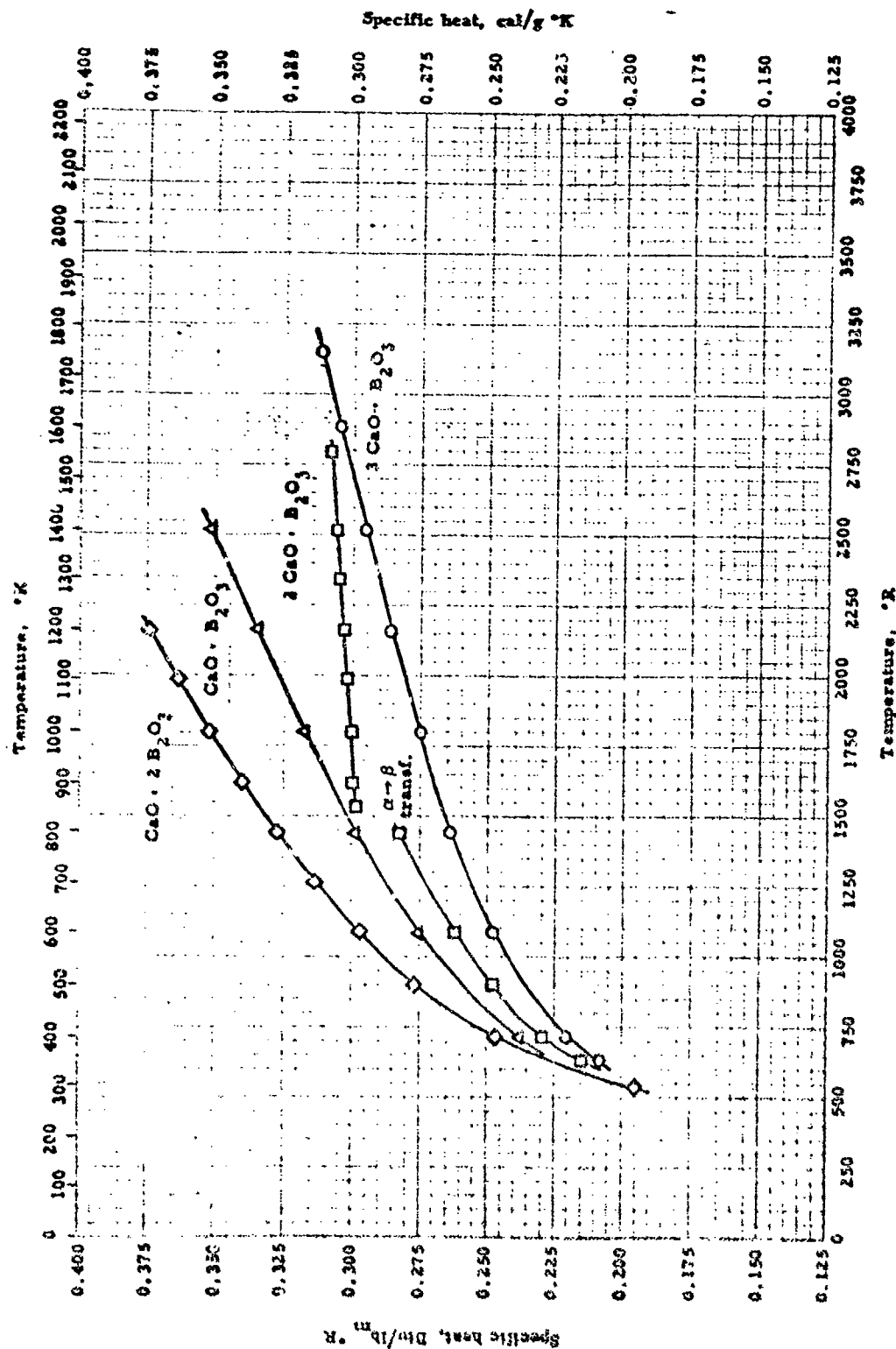
REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	King, E. O., D. R. and Cook, O. A.	48-7	2268-3168	Calcium borate	ΔH : enthalpy difference at MP between liquid and solid phases. Enthalpy by drop method. MP: not given	

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SPECIFIC HEAT -- CALCIUM BORATE

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SPECIFIC HEAT -- CALCIUM BORATE

REFERENCE INFORMATION

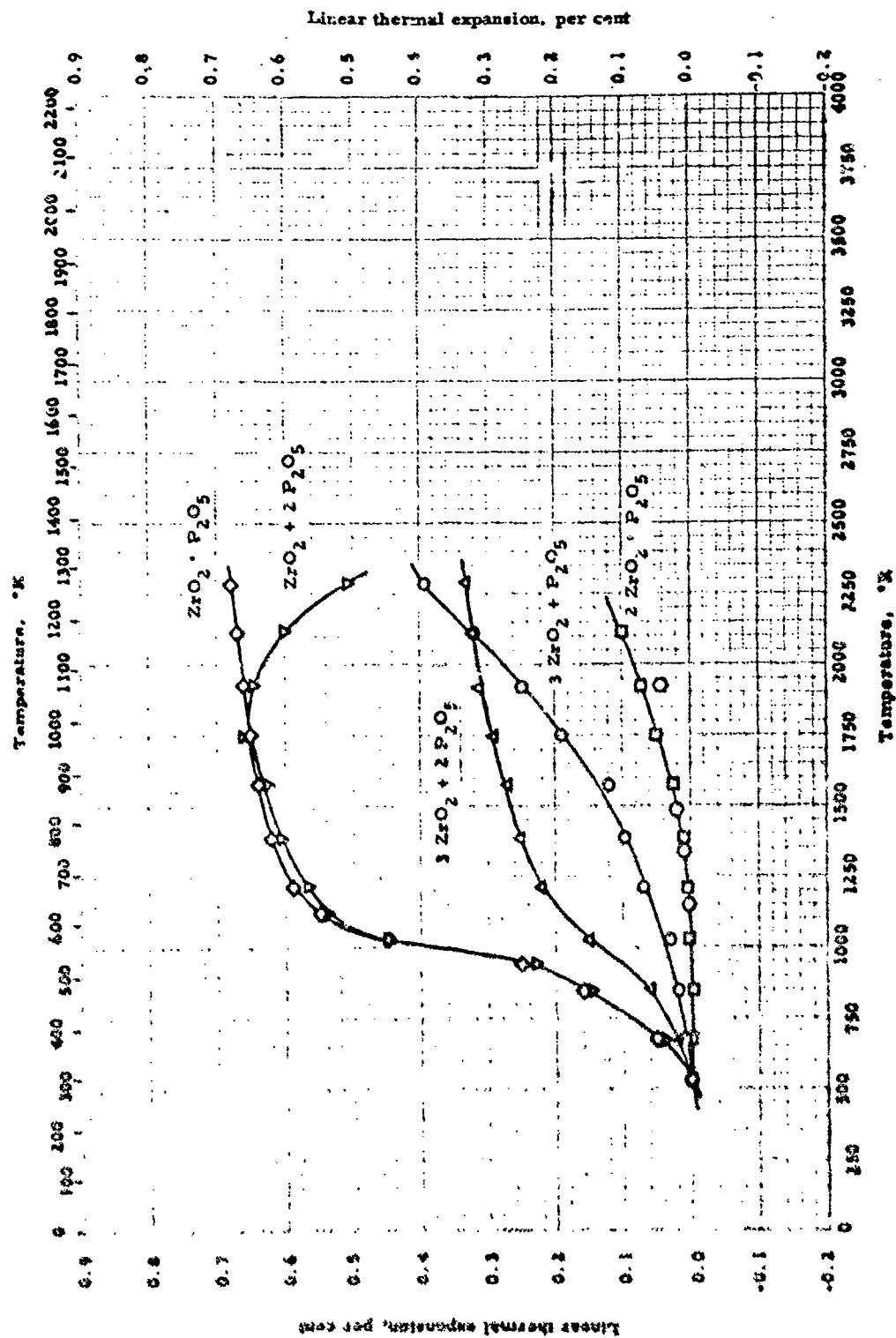
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
48-7	King, E. G., Torgerson, D. R. and Cook, O. A.	670-3340	3CaO · B ₂ O ₃ ; Colemanite	Drop method; copper block calorimeter	
48-7	Ibid.	687-3278	2CaO · B ₂ O ₃ ; α and β crystals	Same as above	
48-7	Ibid.	784-3020	CaO · B ₂ O ₃	Same as above	
48-7	Ibid.	665-3240	CaO · 2B ₂ O ₃	Same as above	

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LINEAR THERMAL EXPANSION -- ZIRCONIUM PHOSPHATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM PHOSPHATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Material Composition	Test Method	Remarks
54-48	Harrison, D. E., McKinstry, H. A., and Hummel, F. A.	528-2292	3 ZrO ₂ + P ₂ O ₅ ; 72.2% ZrO ₂ ; 27.8% P ₂ O ₅	Fused silica dilatometer	Mixture calcined 4 hr. at 1550°C
54-48	Idid.	528-2112	2 ZrO ₂ · P ₂ O ₅ ; 63.4% ZrO ₂ ; 36.5% P ₂ O ₅	Same as above	Compound, Treated as above
54-48	Idid.	528-2292	3 ZrO ₂ + 2 P ₂ O ₅ ; 56.5% ZrO ₂ ; 43.5% P ₂ O ₅	Same as above	Mixture calcined 10 hr. at 1380°C
54-48	Idid.	528-2292	ZrO ₂ · P ₂ O ₅ ; 46.5% ZrO ₂ ; 53.5% P ₂ O ₅	Same as above	Compound, Treated as above
54-48	Idid.	528-2292	ZrO ₂ + 2 P ₂ O ₅ ; 30.3% ZrO ₂ ; 69.7% P ₂ O ₅	Same as above	Mixture calcined 10 hr. at 1300°C
46-13	Hummel, F. A. and Henry, E. C.	528-1932	Zirconium phosphate	Fused silica dilatometer	Calcined at 1400°C

PROPERTIES OF CALCIUM HAFNATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	416 lb _m /ft ³	6.5 g/cm ³
Melting Point	4940°R	2740°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft³ g/cm³ Porosity, %
 O 358 5.73 12.3

Melting Point: °R °K
 O 4938 ± 36 2743 ± 20

Heat of Fusion: Btu/lb_m cal/g

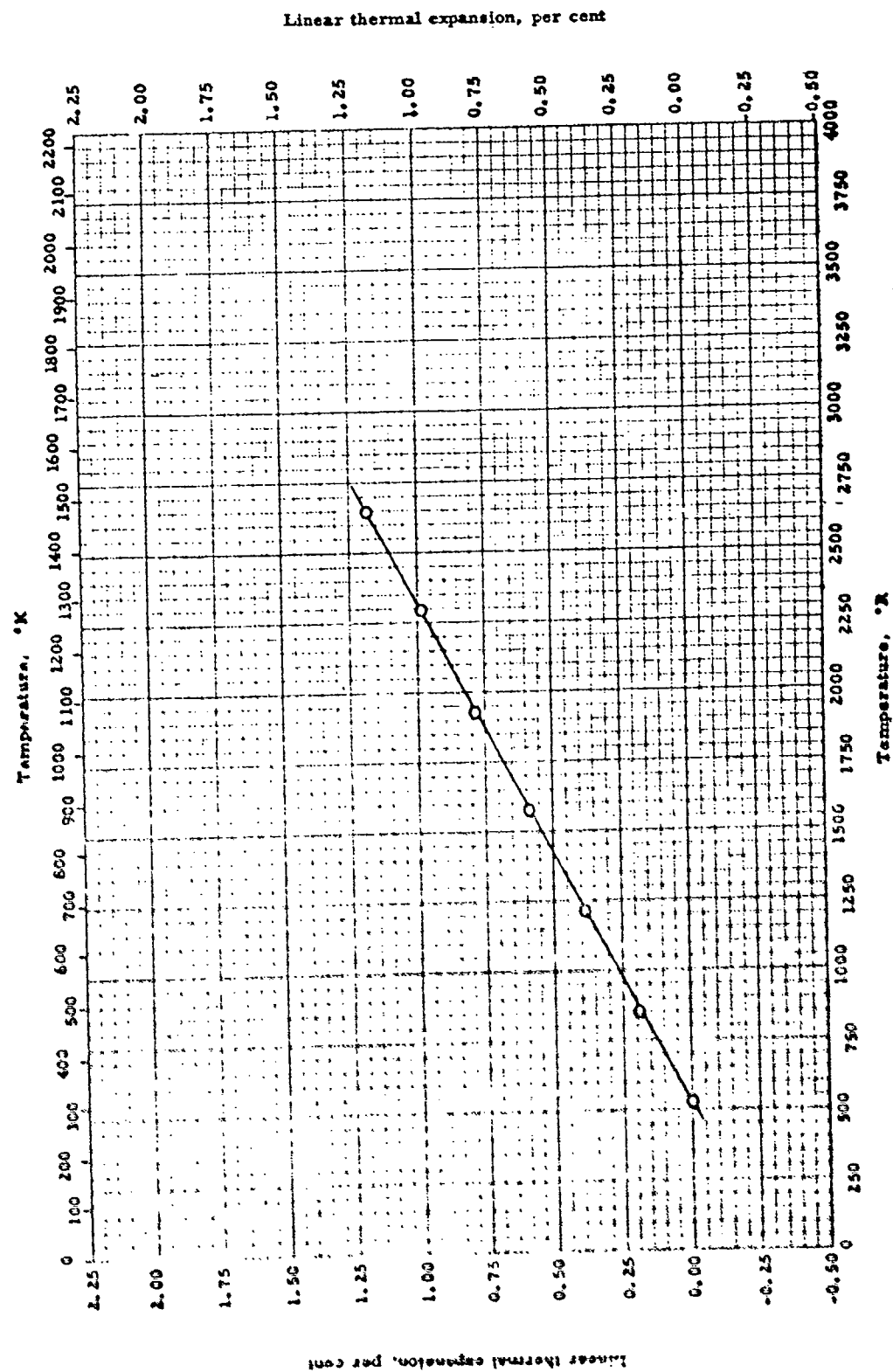
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF CALCIUM HAFNATE

REFERENCE INFORMATION

Sym- bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., Doney, L. M., and Johnson, J. R.	54-45	Room	CaHfO ₃	ρ: Not given MP: not given	Equimolar composition of CaO and HfO ₂ , calcined 2 hr. at 1550° C, reground to 200 mesh, pressed with 5% water and 2% dextrin: fired 2 hr. at 1550° C, cooled slowly. Orthorhombic crystal struc- ture

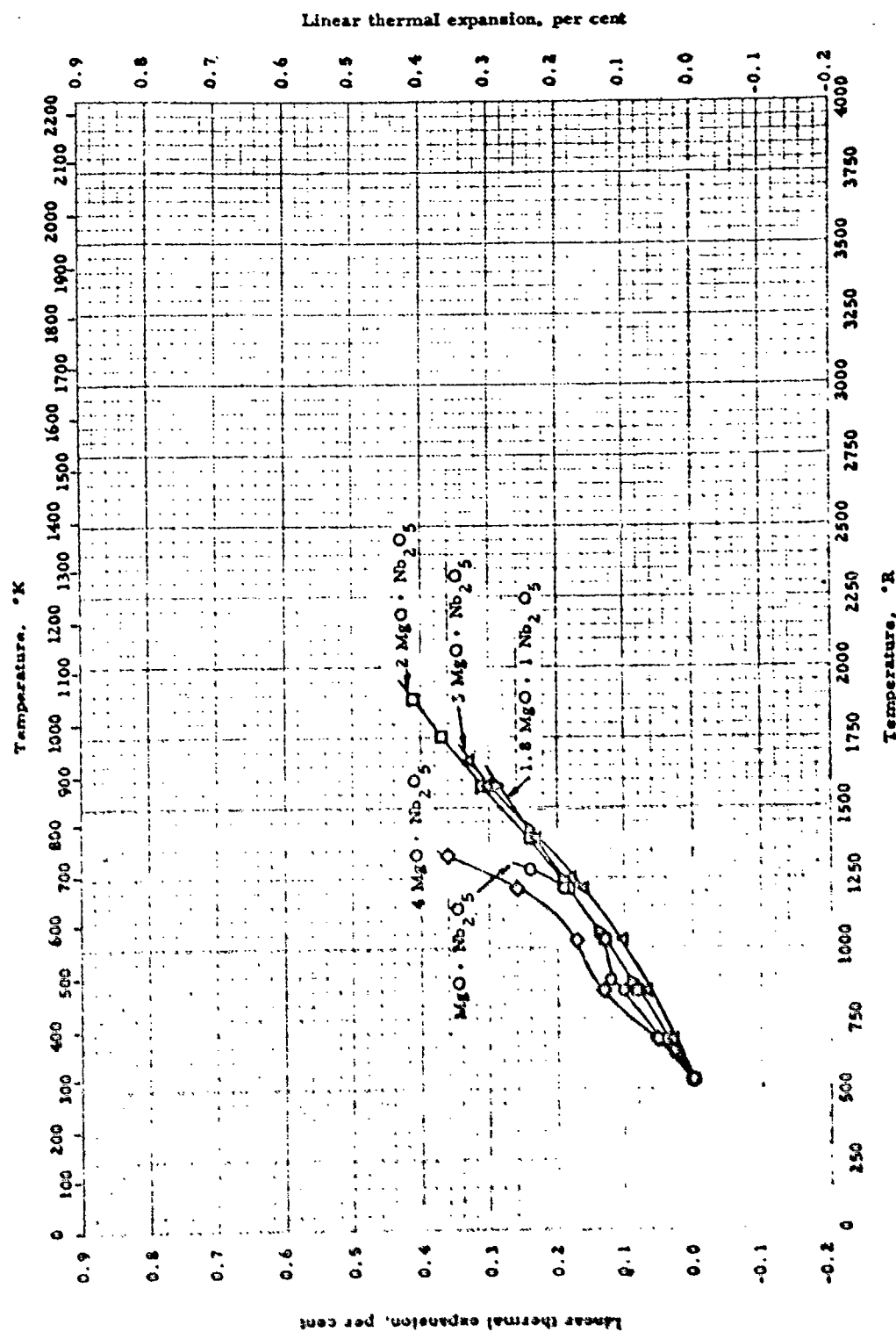


LINEAR THERMAL EXPANSION -- CALCIUM HAFNATE

LINEAR THERMAL EXPANSION -- CALCIUM HAFNATE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-46	Curtis, C. E., Doney, L. M., and Johnson, J. R.	528-2652	CaHfO ₃ . $\rho = 358 \text{ lb/ft}^3$	Sapphire dilatometer	



LINEAR THERMAL EXPANSION -- MAGNESIUM NIOBATE

LINEAR THERMAL EXPANSION -- MAGNESIUM NIOBATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
92-11	Durbia, E. A. and Harman, C. G.	92-11	528-1284	86.8% Nb ₂ O ₅ ; 13.2% MgO	Interferometer	MgO · Nb ₂ O ₅ Fired 2 hr. at 1450°C, cooled in 24 hr.
92-11	Durbia.	92-11	528-1878	76.7% Nb ₂ O ₅ ; 23.3% MgO	Same as above	2 MgO · Nb ₂ O ₅ Fired 2 hr. at 1500°C, cooled in 24 hr.
92-11	"	92-11	528-1662	68.7% Nb ₂ O ₅ ; 31.3% MgO	Same as above	3 MgO · Nb ₂ O ₅ Fired as above
92-11	Durbia.	92-11	528-1338	62.2% Nb ₂ O ₅ ; 37.8% MgO	Same as above	4 MgO · Nb ₂ O ₅ Fired as above
92-14	Durbia, E. A., Wagner, H. E., and Harman, C. G.	92-14	528-1782	78.55% Nb ₂ O ₅ ; 21.45% MgO; prepared from c.p. raw materials	Interferometer	MgO · Nb ₂ O ₅ + 2 MgO · Nb ₂ O ₅ (in proportion of 1.8 MgO to 1 Nb ₂ O ₅) calcined 2 hr. at 1220°C. Fired at 1495°C

PROPERTIES OF CALCIUM ZIRCONATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	290 lb _m /ft ³	4.6 g/cm ³
Melting Point	4686°R	2603°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	281.5	4.509
□	278.4	4.460
Δ	291	4.66

<u>Melting Point:</u>	°R	°K
Δ	4686	2603

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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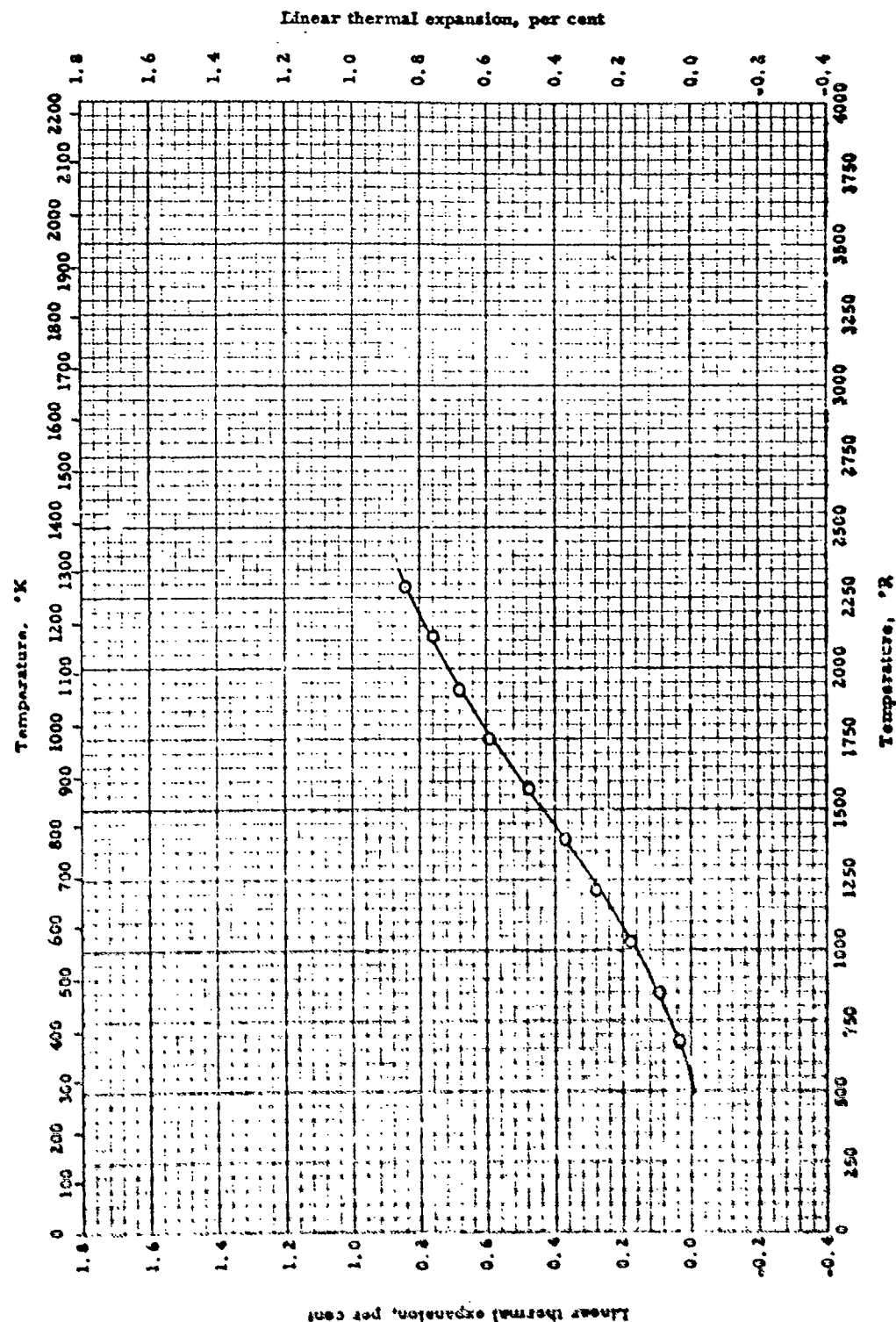
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF CALCIUM ZIRCONATE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nadler, M. R.	53-57	Room	CaZrO ₃ . Made from ZrO ₂ (cont. 0.097% Si; 0.043% Ti; 0.030% Fe; 0.020% Mg) and CaCO ₃ (cont. 0.16% Mg; 0.001% Fe)	p: pycnometer	Mixed from equal moles of ZrO ₂ and CaCO ₃ , pressed at 10,000 psi, fired at 1750°C
□	Ibid.	53-57	Room	Same as above	p: same as above	Mixed from equal moles of ZrO ₂ and CaCO ₃ , pressed at 10,000 psi; fired at 1850°C
△	Nadler, M. R. and Fitzsimmons, E. S.	55-29	Room	99% pure CaZrO ₃ ; 0.08% Mg	p: pycnometer MP: observation during heating with oxyacetylene; optical pyrometer	Mixed from equal moles of ZrO ₂ and CaCO ₃ ; fired 1 hr. at 1850°C



LINEAR THERMAL EXPANSION -- BARIUM ZIRCONATE

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LINEAR THERMAL EXPANSION -- BARIUM ZIRCONATE

REFERENCE INFORMATION

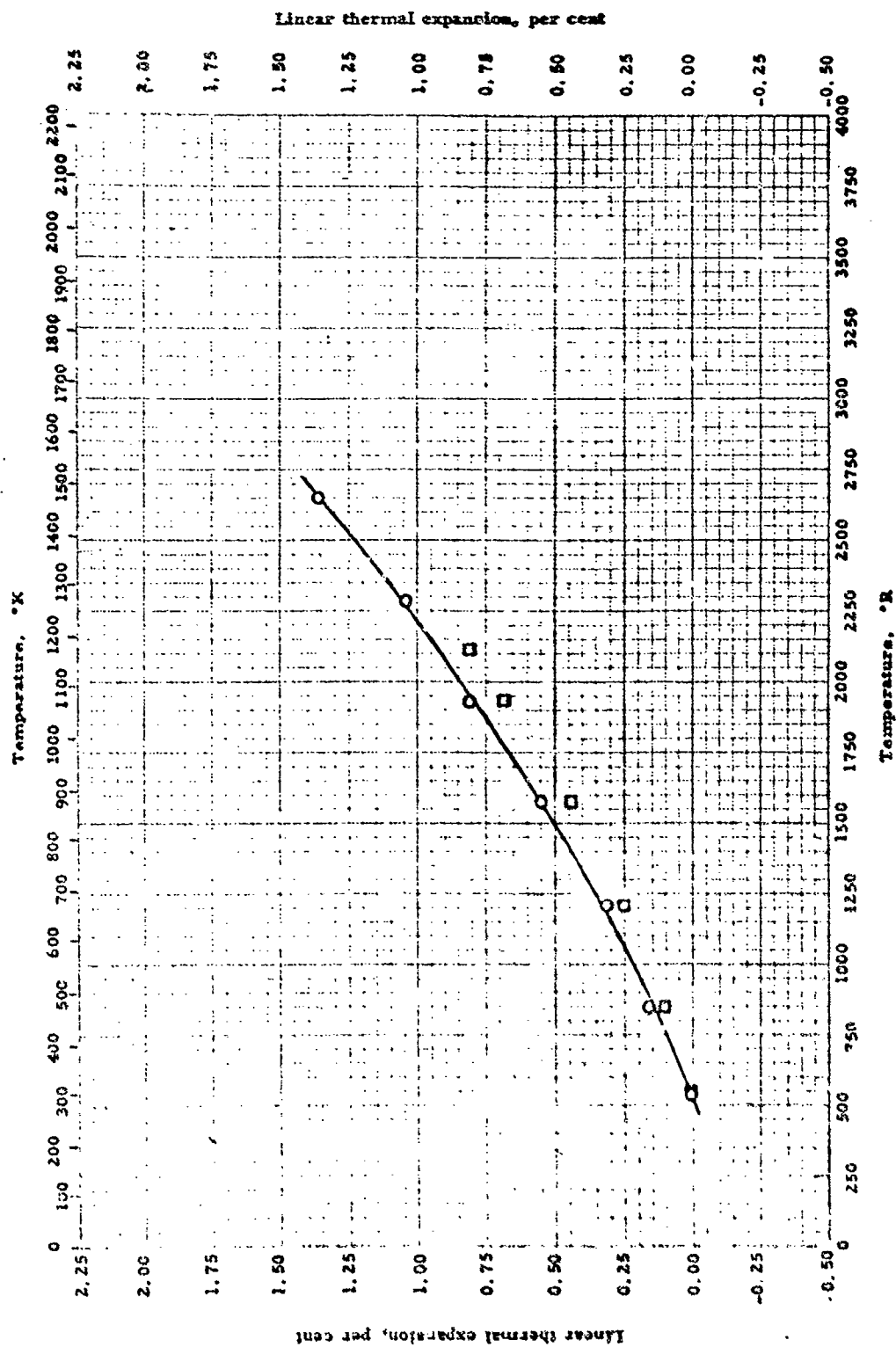
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
48-4	Beattie, R., McKinnon, H. et al.	48-4	672-2292	2BaO · ZrO ₂	Not given	Fired 1 hr. at 1350°C

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LINEAR THERMAL EXPANSION -- CALCIUM ZIRCONATE

LINEAR THERMAL EXPANSION -- CALCIUM ZIRCONATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
53-40	Nadler, M. R. and Fitzsimmons, E. S.	53-40	537-2452	99% pure CaZrO_3 ; prepared from c.p. ZrO_2 (0.1-0.5% CaO) and c.p. CaCO_3 (0.16% Mg)	Telemicroscope	Fired 1 hr. at 1650°C
53-37	Nadler, M. R.	53-37	555-2114	Prepared from c.p. ZrO_2 (0.09% Si ; 0.04% Ti ; 0.03% Fe ; 0.02% Mg) and c.p. CaCO_3 (0.16% Mg ; 0.001% Fe)	Telemicroscope	Pressed at 10,000 psi; fired to 1750°C

PROPERTIES OF ALUMINUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	230 lb _m /ft ³	3.68 g/cm ³
Melting Point	3890°R	2160°K
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density: lb_m/ft³ g/cm³
 O 229.4 3.681

Melting Point: °R °K
 O 3893 ± 18 2163 ± 10

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF ALUMINUM TITANATE

REFERENCE INFORMATION

S/m Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Aron, V. A. and Pechogin, A. V.	53-465	Room 1870-1910	Al ₂ TiO ₃ (Al ₂ O ₃ · TiO ₂)	p: not given MP: not given	Fired at 1600°C

60-104

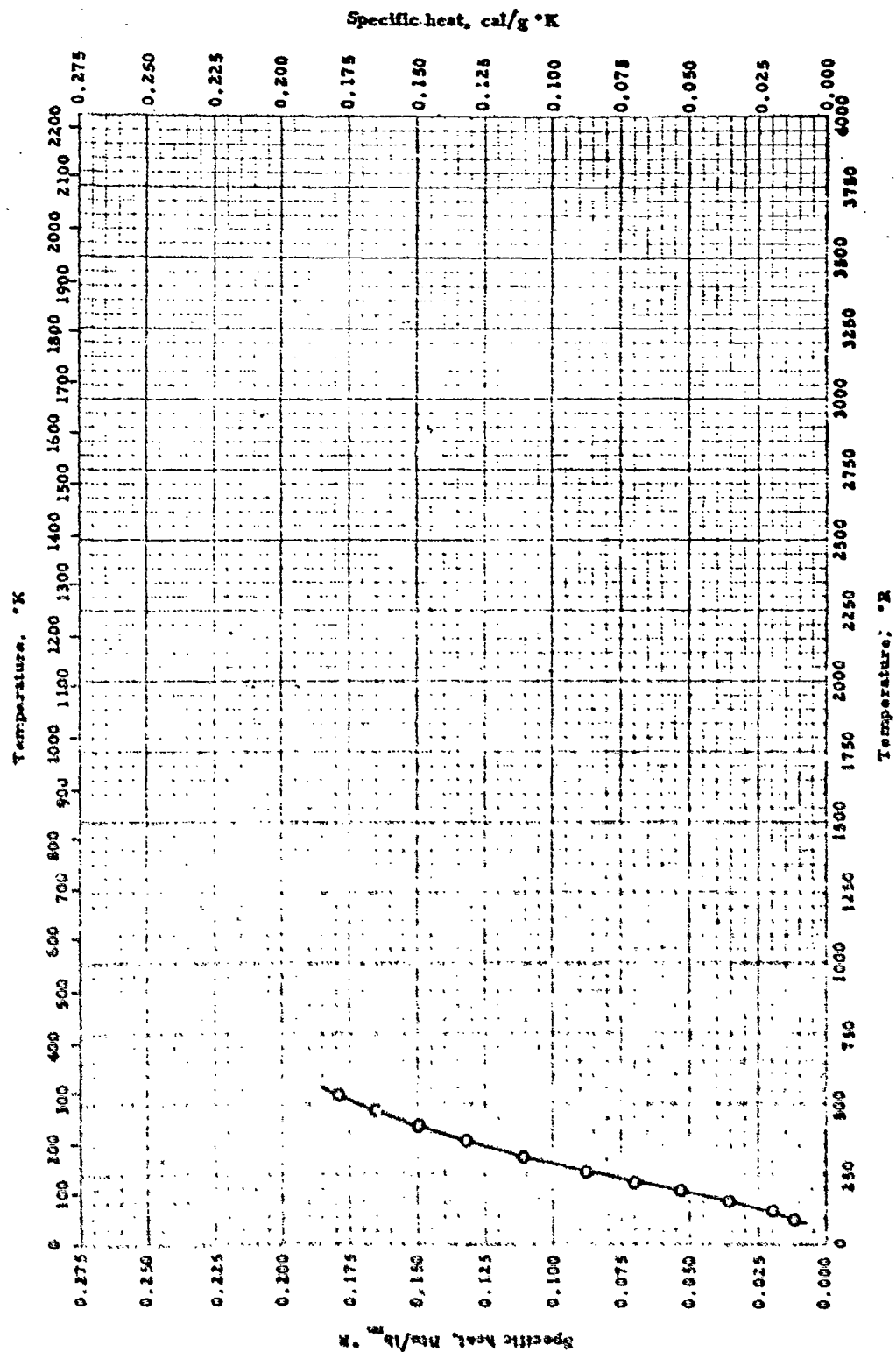
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SPECIFIC HEAT -- ALUMINUM TITANATE

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SPECTRIC HEAT -- ALUMINUM TITANATE

REFERENCE INFORMATION

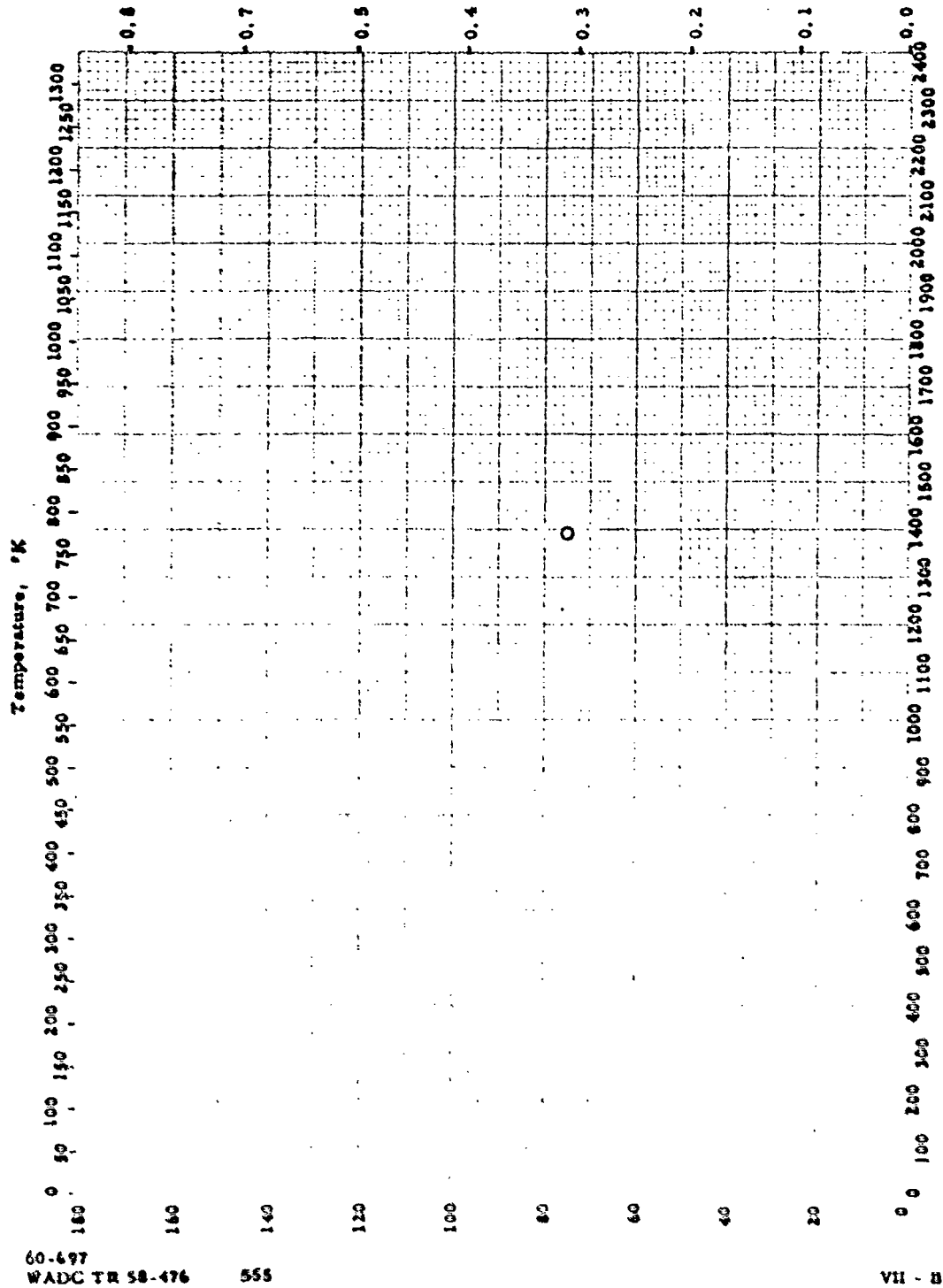
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Klag, E. O.	55-42	96-556	Al ₂ TiO ₅ ; 43.95% TiO (cf. theor. 43.93%); 0.06% SiO	Guarded sample	

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Thermal Conductivity, cal/sec cm. °K



Temperature, °R

Thermal Conductivity, kcal/hr ft. °R

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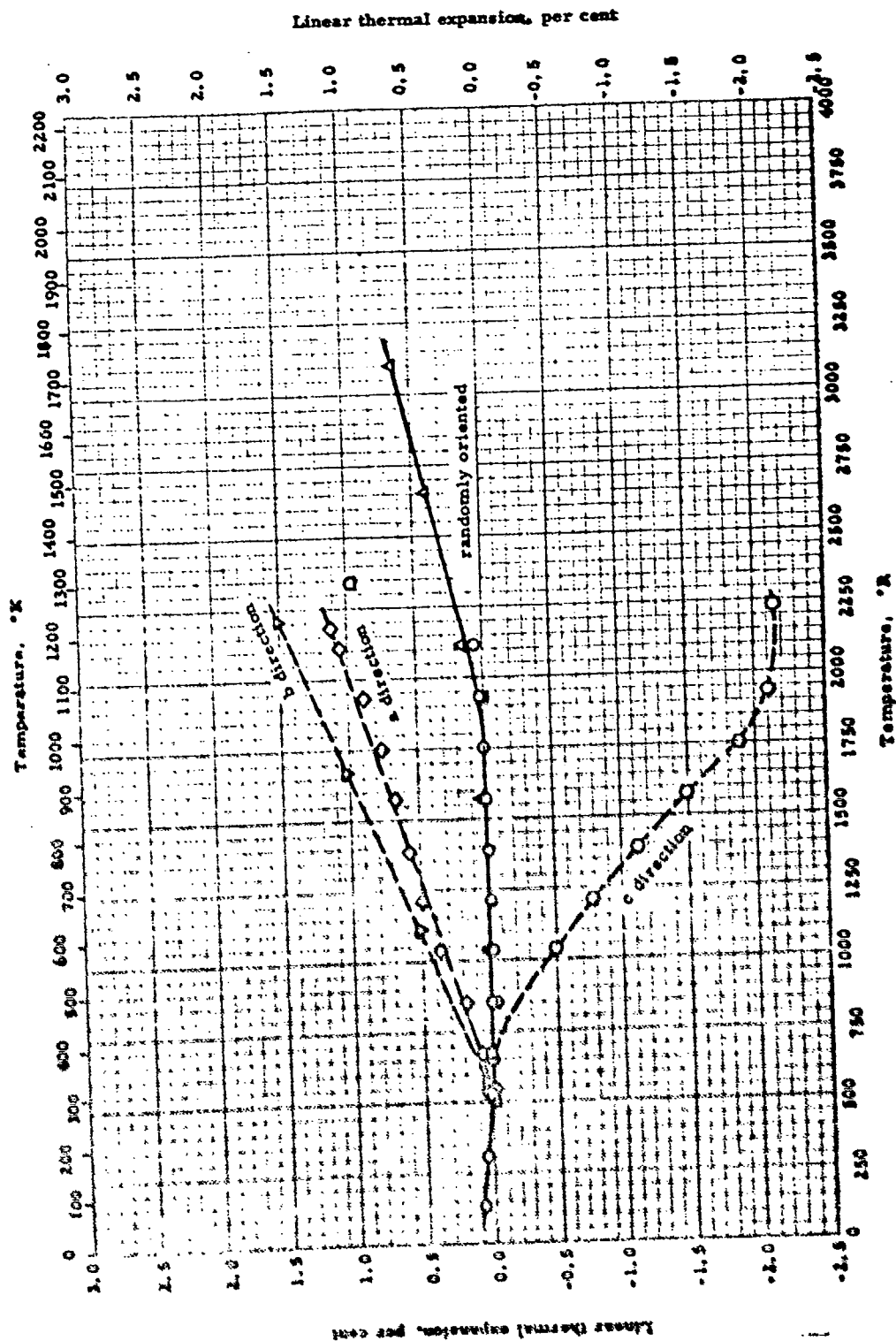
Thermal Conductivity, kcal/hr ft. °R

555
947-85 M.Y.V.M.
169-09

THERMAL CONDUCTIVITY -- ALUMINUM TITANATE

REFERENCE INFORMATION

Sym Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Buessem, W. R., Zachart, W. R. et al.	52-133	1392	Aluminum titanate	Simple measurement of heat flow in shock test rig	



LINEAR THERMAL EXPANSION -- ALUMINUM TITANATE

LINEAR THERMAL EXPANSION -- ALUMINUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
50-12	Koch, W. J. and Hartman, C. G.	132-2112	Al ₂ O ₃ · TiO ₂ 56.1% Al ₂ O ₃ ; 43.9% TiO ₂	Not given	Equimolar mix of Al ₂ O ₃ and TiO ₂ ball-milled, dried at 110°C, 5% wax added as binder, pressed at 10,000 psi, fired to 650°C in 8 hr. to remove binder, then to 1820°C in 26 hr., held 1 hr., furnace cooled to room temp, crushed, ground to 6µ, dried, pressed, fired to 1700°C in 29 hr., held 1 hr.
51-145	Green, V. A. and Padgett, A. K.	492-1922	Al ₂ O ₃ · TiO ₂	Not given	Fired at 1600°C
54-7	Wilmshurst, O. J. and Ault, M. N.	1032-2102	Al ₂ O ₃ · TiO ₂	Telemicroscopes sighting on ends of sample. Temp. meas. by Pt, Pt-Rh thermocouples	Fine grain
52-133	Duesenberg, W. R., Earhart, W. R. et al.	537-2184	Aluminum Titanate body. Porosity = 18%	Probably by X-ray measurement of lattice dimensions of unit cell.	Dry pressed, held 5 hr. at 1400°C. Orthorhombic structure from X-ray photographs. Meas. in direction "a"
52-133	Did.	518-1101	Same as above	Same as above	Same as above, but meas. in direction "b"
52-133	Did.	546-1124	Same as above	Same as above	Same as above, but meas. in direction "c"
52-133	Did.	546-1164	Same as above	Same as above	Same as above, but random oriented

PROPERTIES OF BARIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	3400°R *	1890°K *
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

* Value for BaTiO₃; for others see Reported Values below.

REPORTED VALUES

Density: lb_m/ft³ g/cm³

<u>Melting Points</u>		°R	°K	Material
	○	3372	1873	BaTiO ₃
	□	3404	1891	BaTiO ₃
	△	3394	1885	BaTiO ₃
	◇	3408	1893	BaTiO ₃
	▽	3439	2133	BaTiO ₃
	○	3336	1853	Ba ₂ TiO ₄

Heat of Fusion: Btu/lb_m cal/g

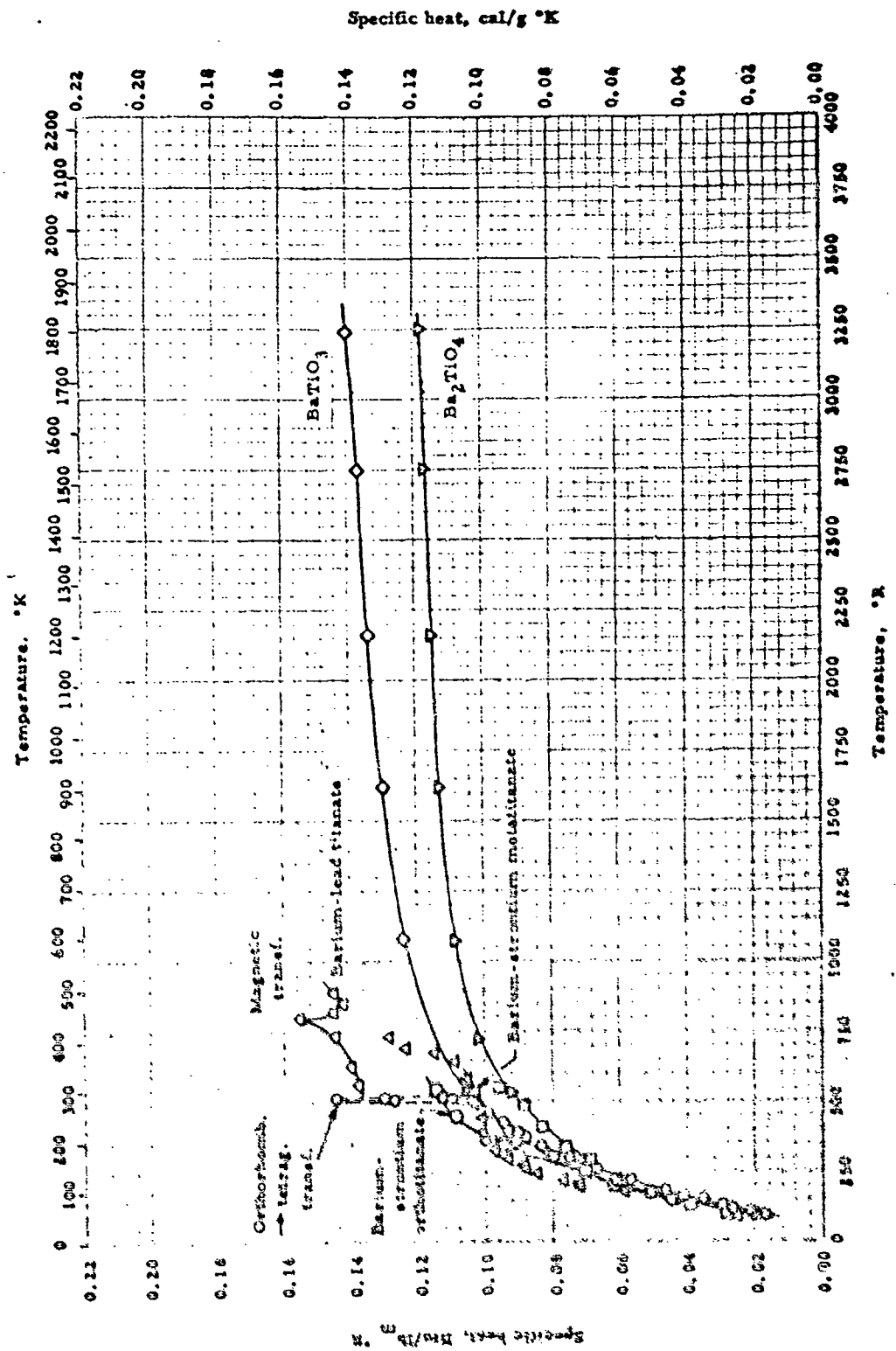
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF BARIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Guarnaschani, J. A. and DeVries, R. C.	57-62	1373	99.5% BaTiO ₃ ; 0.4% SrTiO ₃	MP: 3 methods (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouple (3) visual with optical pyrometer MP: same as above	
Q	DeVries, R. C. and Roy, R.	55-72	1404	BaTiO ₃ ; barium metatitanate	MP: break in time-temp. curve; Pt-Rh thermocouple	Prepared from c.p. grade BaCO ₃ and TiO ₂ by mixing and sintering for 24 hr. at about 100°C below solidus
Δ	Ross, D. E. and Roy, R.	55-73	1394	BaTiO ₃	MP: visual observation; optical pyrometer; melted on resistance heated Pt-Rh strip	Same as above
Q	Did.	55-73	1405	Same as above	Same as above	Prepared as above. Auth. suspects reaction with heater strip
▽	Did.	55-73	1399	Ba ₂ TiO ₆ ; barium orthotitanate	MP: 3 methods. (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouple (3) visual with optical pyrometer	
Q	DeVries, R. C. and Roy, R.	55-72	1396	82% BaTiO ₃ ; 18% CaTiO ₃		

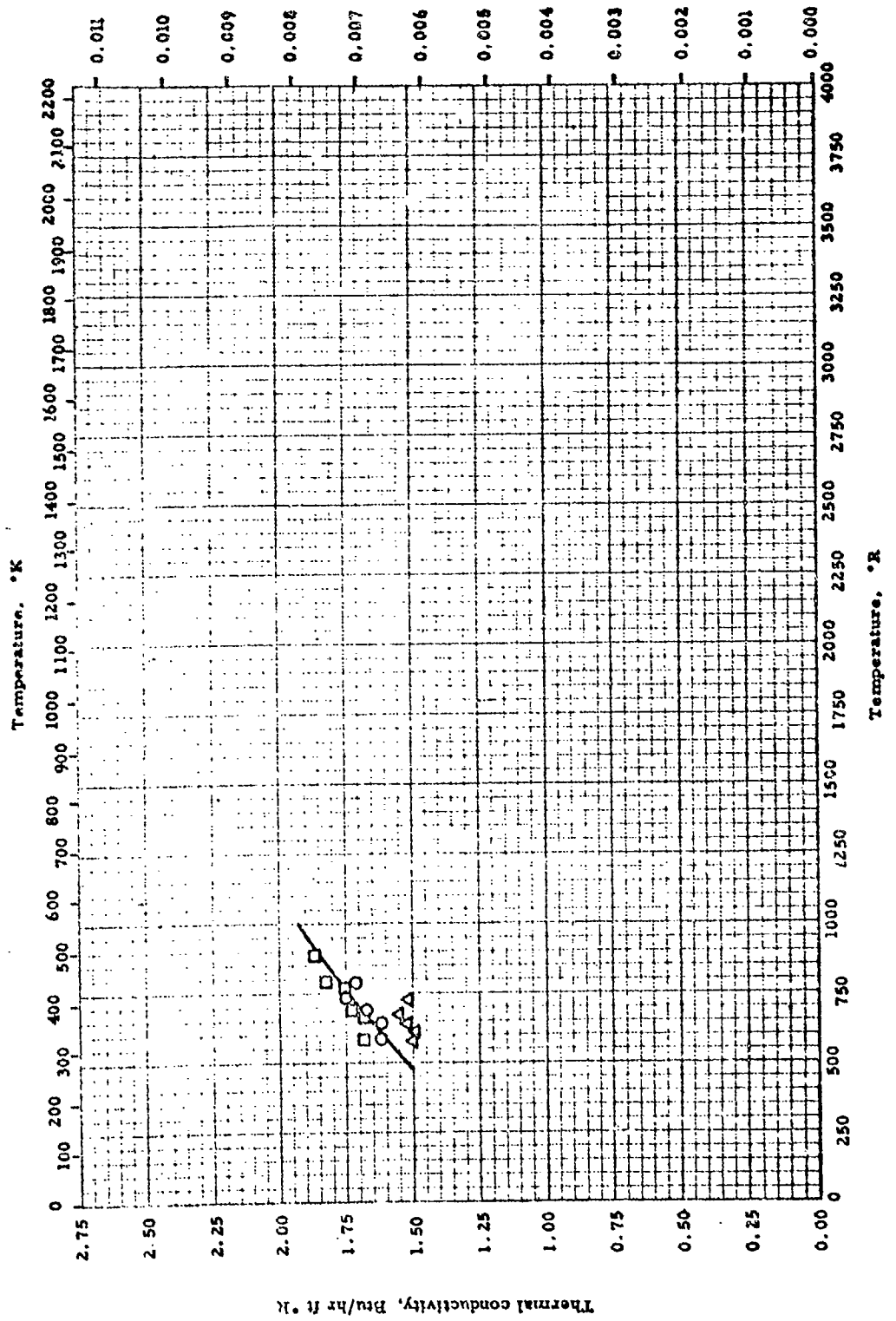


SPECIFIC HEAT -- BARIUM TITANATE

SPECIFIC HEAT -- BARIUM TITANATE

REFERENCE INFORMATION

By S.A.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Todd, E. S., and Lorenson, R. E.	52-13	6-342	BaTiO ₃ ; 99.7% pure	Guarded sample	Prepared from reagent grade barium hydroxide, and titania (99.8% pure after ignition) by prolonged heating at 1350 C. Auth. est. accuracy 0.1%
○	Coughlin, J. P., and Orr, R. L.	52-13	440-1296	BaTiO ₃ ; apparently same sample as above	Drop method; copper block calorimeter	
△	Volger, J.	52-58	179-723	BaTiO ₃ ; polycrystalline	Guarded sample	
□	Todd, E. S., and Lorenson, R. E.	52-19	98-342	BaTiO ₃ ; est. 99.2% pure; 20.80 at. % TiO ₂ (cf. later. 20.67%); 0.36% CaO; 2.02% SiO ₂ ; no unreacted oxide or metatitanate	Guarded sample	
▽	Coughlin, J. P., and Orr, R. L.	52-13	716-1296	BaTiO ₃ ; apparently same sample as above	Drop method; copper block calorimeter	
○	Todd, E. S., and Lorenson, R. E.	52-13	98-336	1/4, 1 mol % BaTiO ₃ ; 43.7 mol % SrTiO ₃ ; crystalline solution	Guarded sample	Prolonged heating at 1400°C to assure uniform product, Auth. est. accuracy 0.1%
○	Todd, E. S., and Lorenson, R. E.	52-59	98-336	Equimolar solid solution Ba ₂ TiO ₆ and Sr ₂ TiO ₆ ; 51, 56% Ba ₂ TiO ₆ (99.2% pure); 42.62% Sr ₂ TiO ₆ (99.5% pure)	Guarded sample	
○	Nemura, G., and Sawada, S.	51-10	144-888	80% BaTiO ₃ ; 20% PbTiO ₃	Guarded sample	Fired at 1200-1400°C



Thermal conductivity -- BARIUM TITANATE

THERMAL CONDUCTIVITY -- BARIUM TITANATE

REFERENCE INFORMATION

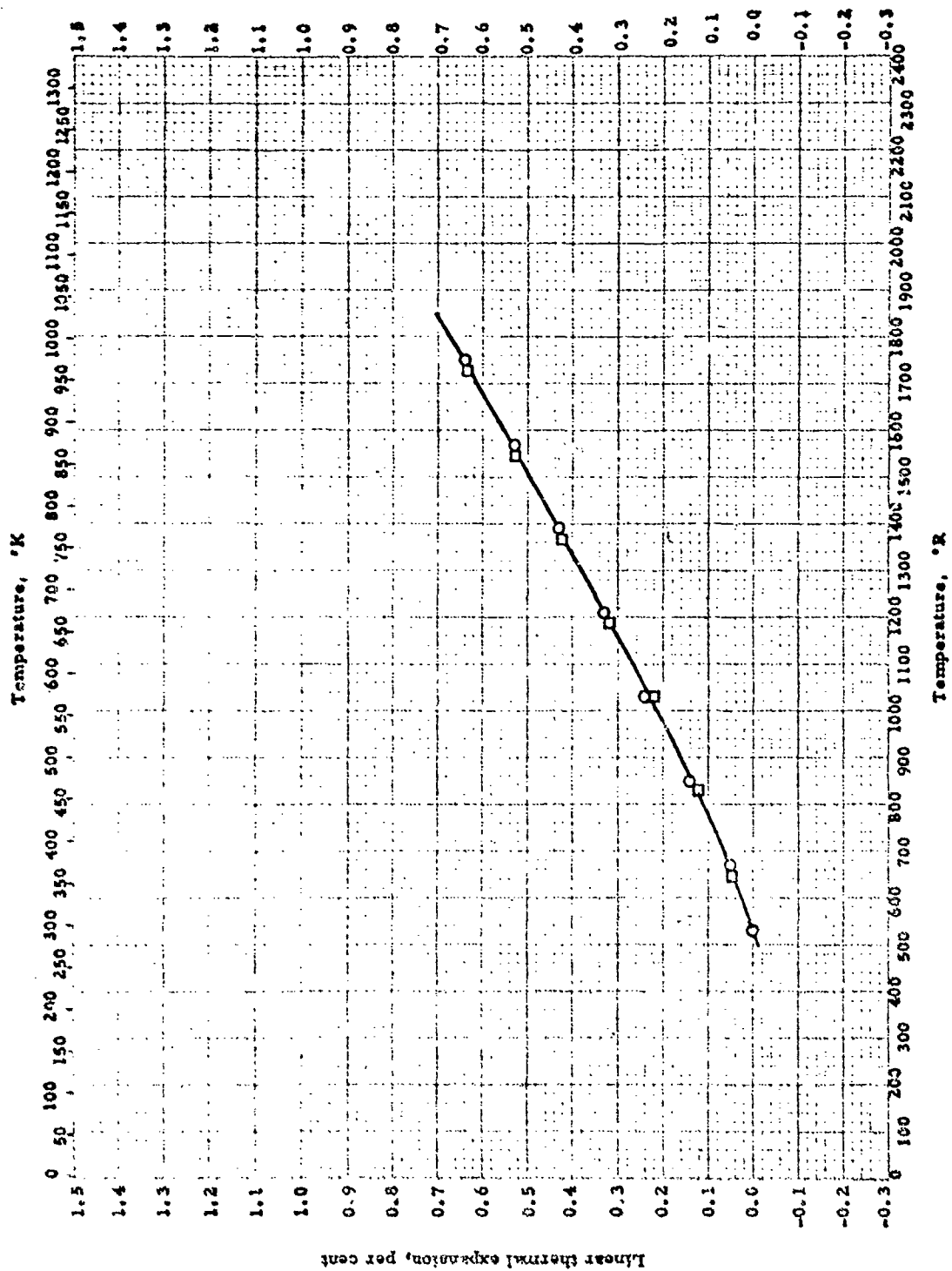
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-43	580-900	Barium titanate	Comparative, rods tested in vac.	Sample 1
□	Ibid.	53-43	580-900	Same as above	Same as above	Sample 2
△	New Jersey Ceramic Research Station	54-69	572-730	Barium titanate	Comparative, rods tested in vac.	

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LINEAR THERMAL EXPANSION -- BARIUM BERYLLIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM BERYLLIUM TITANATE

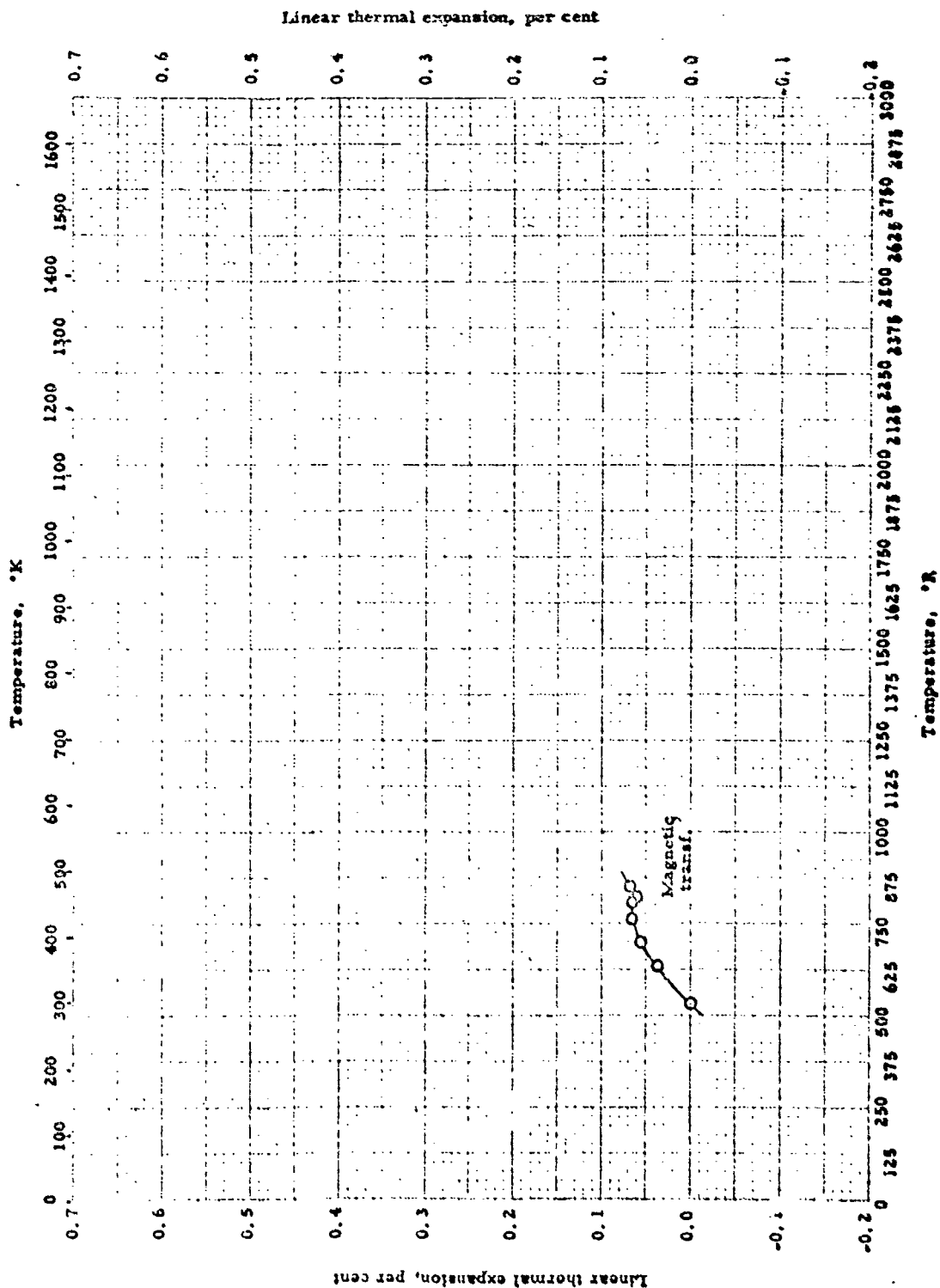
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Burding, E. N., Sheldon, G. R. et al.	51-86	537-1752	50% 5BeO · 4TiO ₂ ; 50% BaO · 5TiO ₂	Interferometer	
□	Ibid.	51-86	537-1752	50% 6BeO · TiO ₂ ; 50% BeO · TiO ₂	Same as above	

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LINEAR THERMAL EXPANSION -- BARIUM LEAD TITANATE

LINEAR THERMAL EXPANSION -- BARIUM LEAD TITANATE

REFERENCE INFORMATION

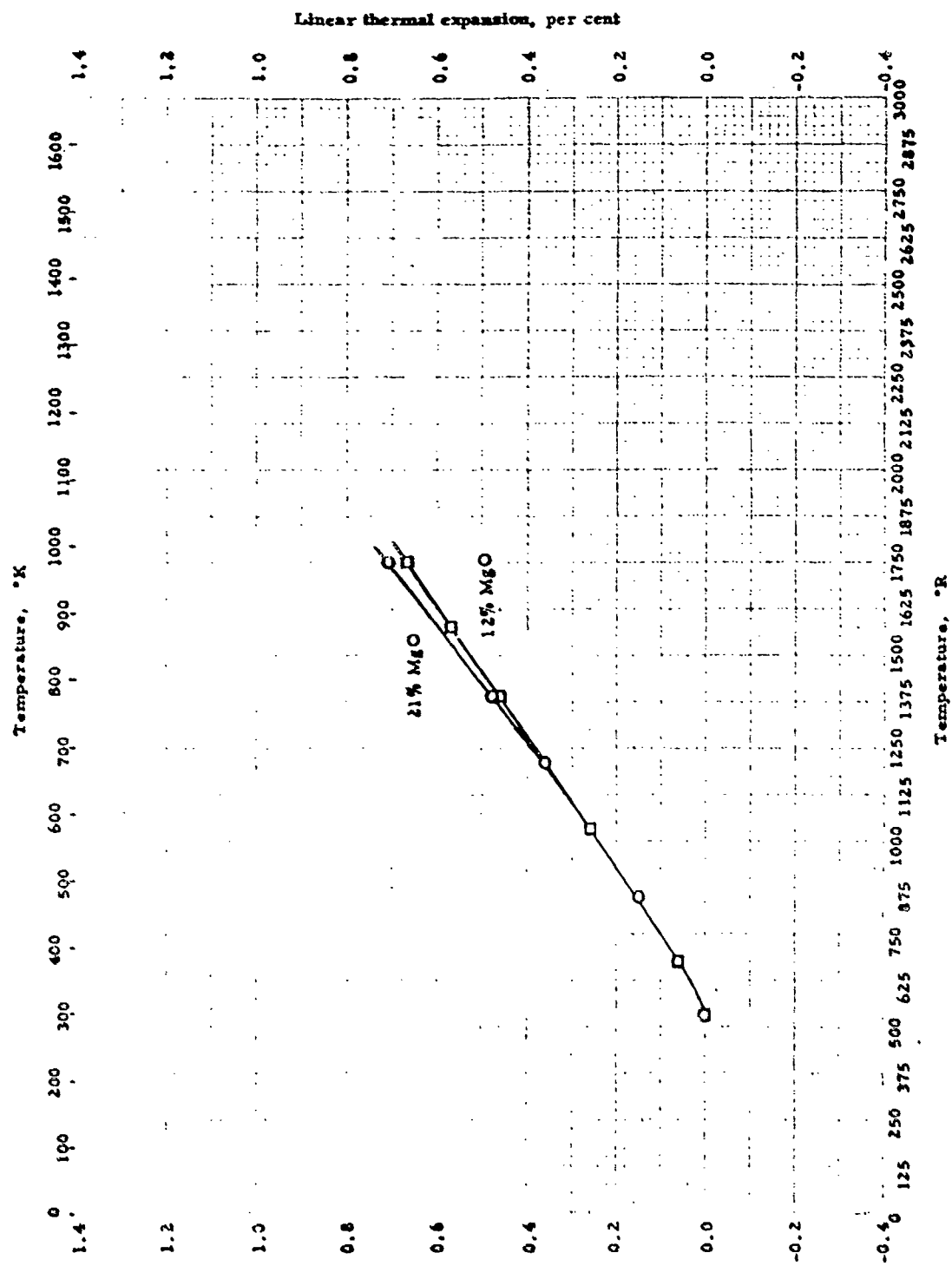
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nomura, S. and Sawada, S.	51-20	528-852	80% BaTiO ₃ ; 20% PbTiO ₃	Cone type dilatometer	

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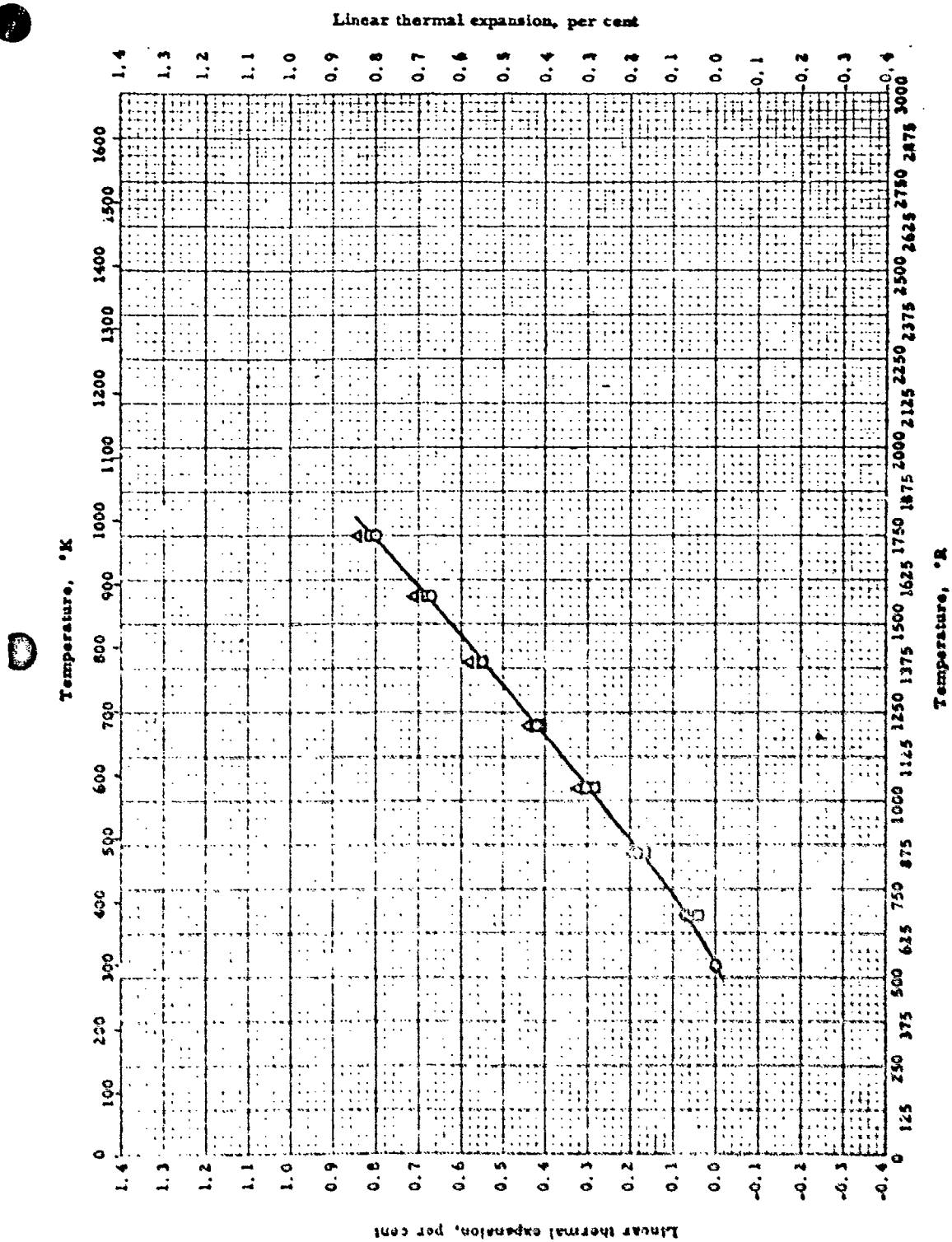


LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Shelton, G. R., and Creamer, A. S. and Bunting, E. N.	48-3	672-1752	54.5% TiO ₂ ; 24.5% BaO; 21.0% MgO	Interferometer	Heated 12 hr. at 1100°C; matured 6 hr. at 1250- 1450°C
□	Ibid.	48-3	672-1752	75.1% TiO ₂ ; 13.0% BaO; 11.9% MgO	Same as above	Same as above

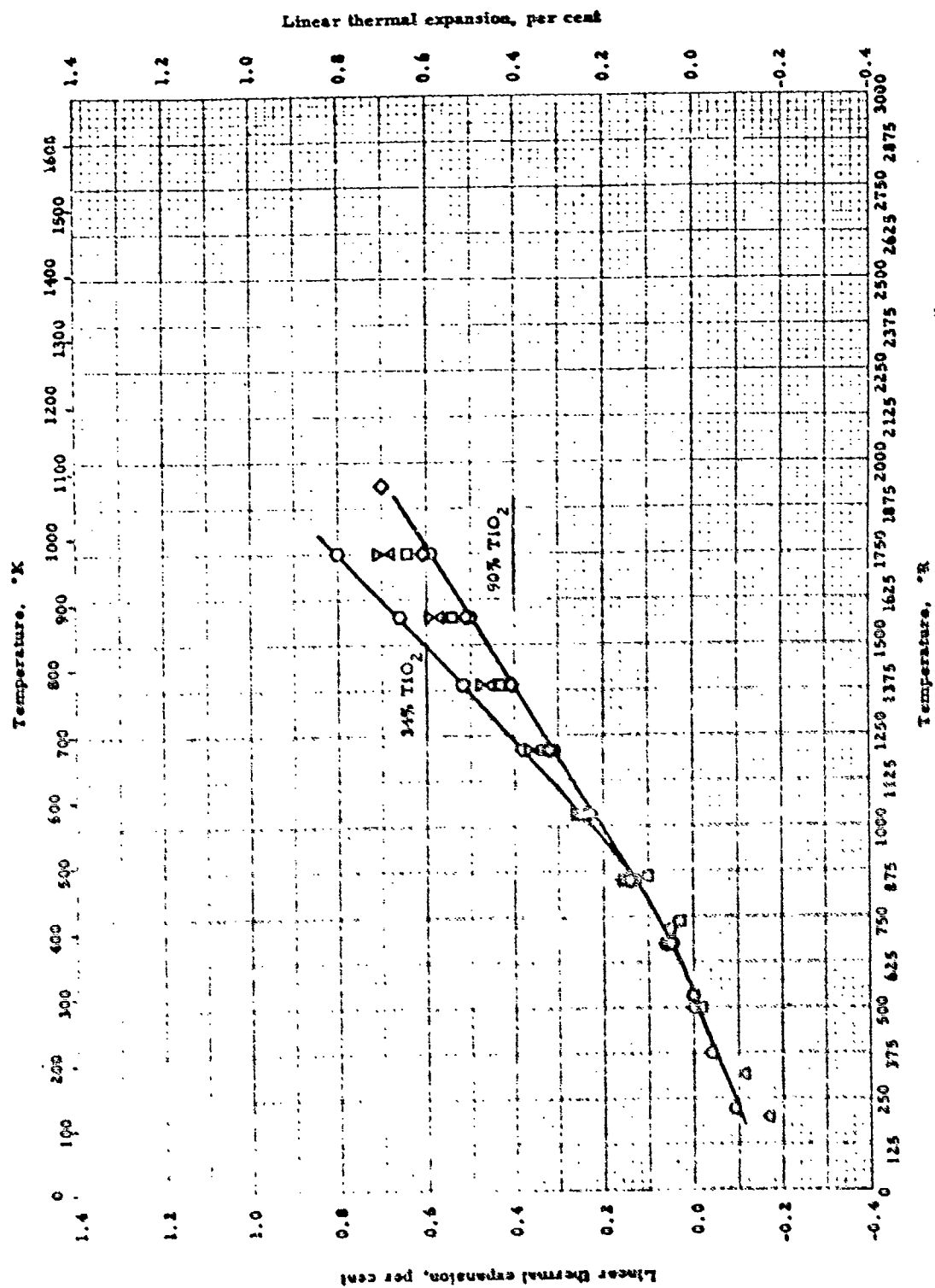


LINEAR THERMAL EXPANSION -- BARIUM STRONTIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM STRONTIUM TITANATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Bunting, E. N., Shelton, G. R., and Greener, A. S.	47-9	672-1752	41.0% TiO ₂ ; 35.0% SrO; 23.7% BaO; prepared from 64.0% (SrO + TiO ₂); 36.0% (BaO + TiO ₂)	Interferometry	Heated 12 hr. at 1100°C, matured 6 hr. at 1250- 1430°C
□	Ibid.	47-9	672-1752	55.1% BaO; 35.8% TiO ₂ ; 9.1% SrO; prepared from 83.8% (BaO + TiO ₂); 16.2% (SrO + TiO ₂)	Same as above	Same as above
Δ	Ibid.	47-9	672-1752	46.7% BaO; 37.0% TiO ₂ ; 16.3% SrO; prepared from 71.0% (BaO + TiO ₂); 29.0% (SrO + TiO ₂)	Same as above	Same as above

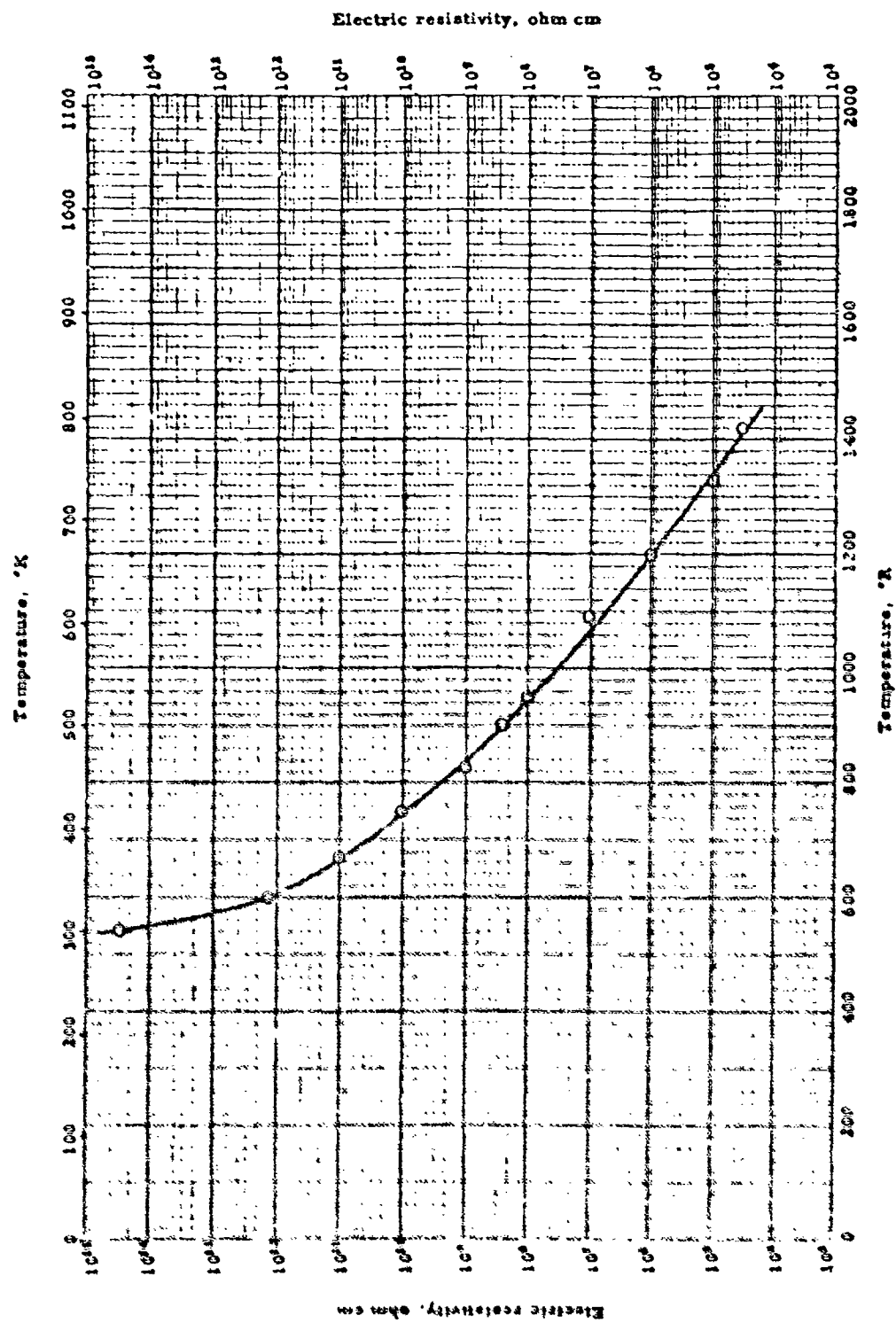


LINEAR THERMAL EXPANSION -- BARIUM TITAZATE

LINEAR THERMAL EXPANSION -- BARIUM TITANATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Quastel, E. M., Nelson, G. R. and Cramer, A. S.	47-9	528-1732	BaO: 18TiO ₂ , 90.4% TiO ₂ ; 9.4% BaO	Interferometer	Heated to 1100°C for 12 hrs., ma- tured at 1250 to 1430°C for 6 hrs.
Q	Did.	47-9	528-1732	BaO: 8TiO ₂ , 93.7% TiO ₂ ; 24.7% BaO	Same as above	Same as above
A	Did.	47-9	528-1732	BaO: 5TiO ₂ , 91.1% TiO ₂ ; 27.7% BaO	Same as above	Same as above
Q	Did.	47-9	528-1932	BaO: 6TiO ₂ , 87.6% TiO ₂ ; 32.4% BaO	Same as above	Same as above
V	Did.	47-9	528-1732	BaO: 3TiO ₂ , 61.0% TiO ₂ ; 39.0% BaO	Same as above	Same as above
O	Did.	47-9	528-1732	BaO: TiO ₂ , 65.7% BaO; 34.3% TiO ₂	Same as above	Same as above
Q	S. J. J. and Takeda, A.	51-87	210-440	BaTiO ₃	Quartz differential dilata- meter	Calculated from 99.1% TiO ₂ and 99.6% BaCO ₃ , sintered at 1400°C. Auth. report transformations at -77°C, 16°C and 125°C
Q	Rhodan, R. G.	51-88	204-328	BaTiO ₃	From vol. change computed from x-ray meas. of unit cell dimensions	Auth. reports transformations at -100°C trigonal → orthorhombic; at 4°C orthorhombic → tetragonal; a third transformation at 120°C



ELECTRIC RESISTIVITY -- BARIUM TITANATE

ELECTRIC RESISTIVITY -- BARIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-152	Waise, E. K. and Aadynaw, M. C.	542-1420	BaTiO ₃	Potential drop, using vacuum tube electrometer	Temp. controlled to $\pm 0.1^\circ\text{C}$

PROPERTIES OF CALCIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	256 lb _m /ft ³ *	4.10 g/cm ³ *
Melting Point.	4038°R	2243°K
Heat of Fusion.		
Heat of Vaporization. . .		
Heat of Sublimation. . . .		

* Handbook of Chemistry and Physics (Ref. 57-60)

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
O 4038 2243

Heat of Fusion: Btu/lb_m cal/g

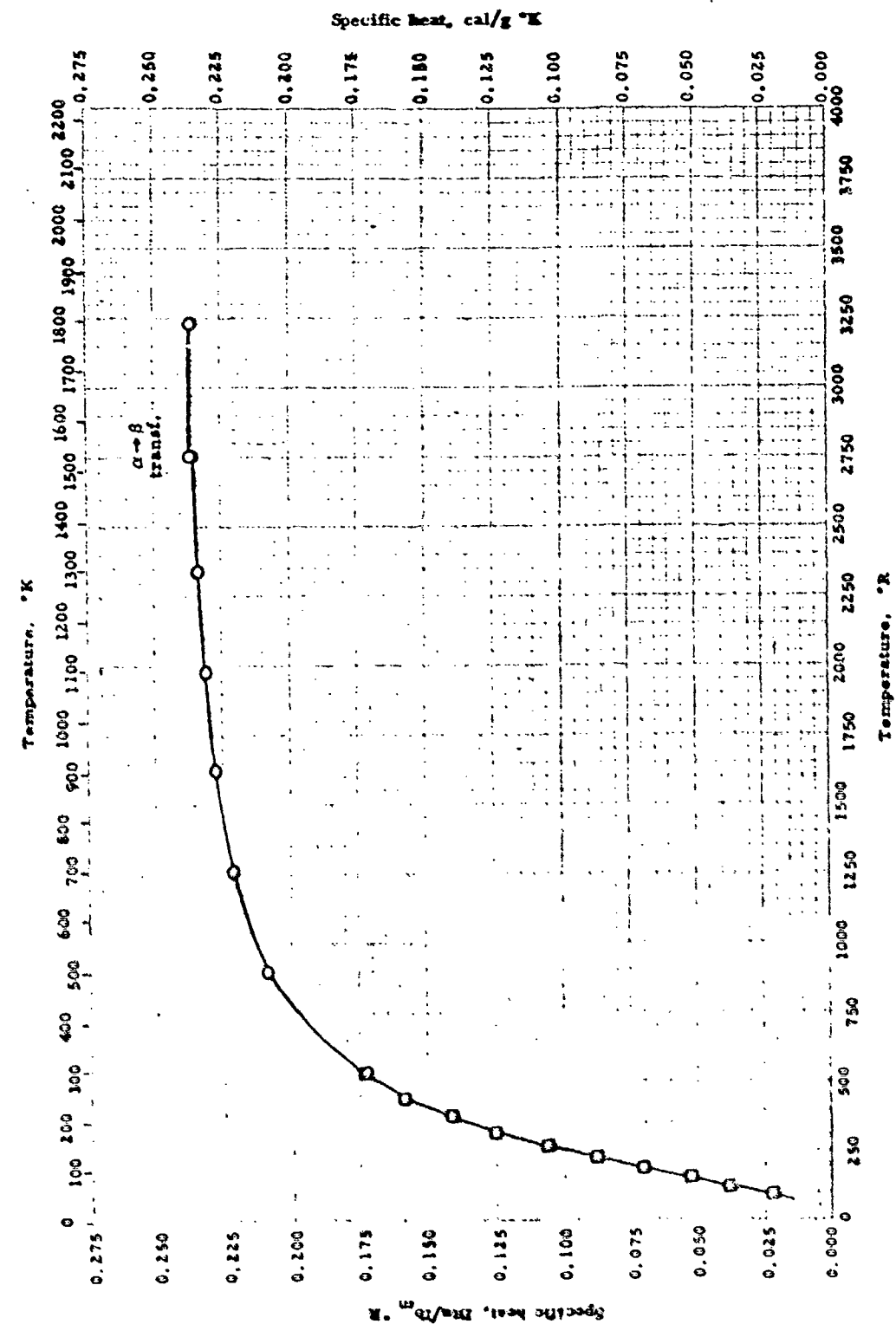
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF CALCIUM TITANATE

REFERENCE INFORMATION

Sym Bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	DeVries, R. C. and Roy, R.	55-72	6038	CaTiO ₃	MP: 3 methods: (1) metallographic inspec- tion of quenched sam- ples (2) visual with cali- brated Pt-Rh thermo- couple (3) visual with op- tical pyrometer	

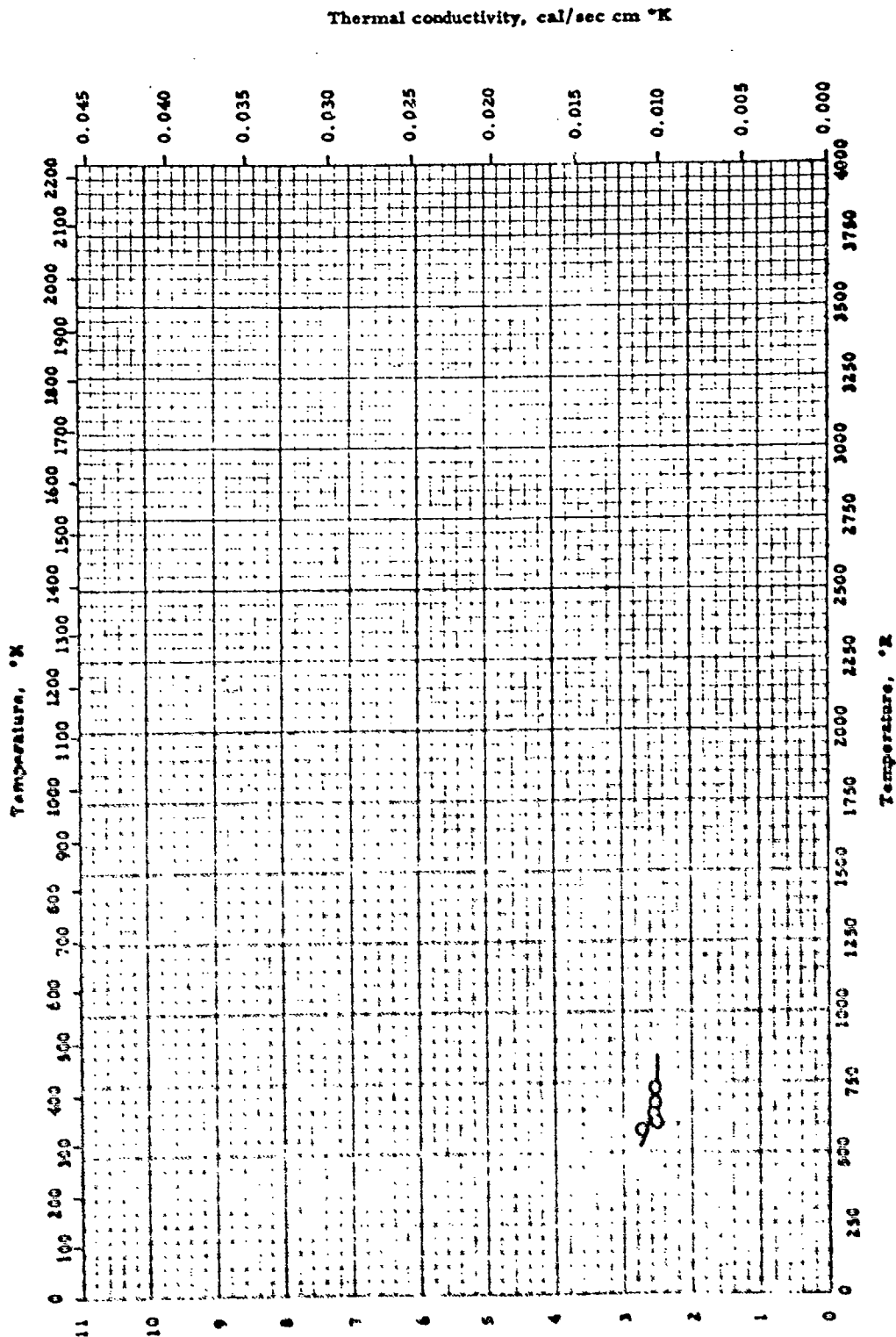


SPECIFIC HEAT -- CALCIUM TITANATE

SPECIFIC HEAT -- CALCIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
46-6	Weylor, B. F. and Cook, D. A.	46-6	231-2330	Calcium metatitanate, CaTiO_3 ; 0.69% CaO ; 0.55% CO_2	Drop method; copper block calorimeter	$\alpha \rightarrow \beta$ transition at 1530 °K with $\Delta h_{\text{transf.}} = 4.04 \text{ Btu/lb}$
55-42	Kling, E. G.	55-42	96-537	Tricalcium dititanate, $\text{Ca}_3\text{Ti}_2\text{O}_7$; 48.65% titania (cf. theor. 48.71%)	Guarded sample	



Thermal conductivity -- CALCIUM TITANATE

THERMAL CONDUCTIVITY -- CALCIUM TITANATE

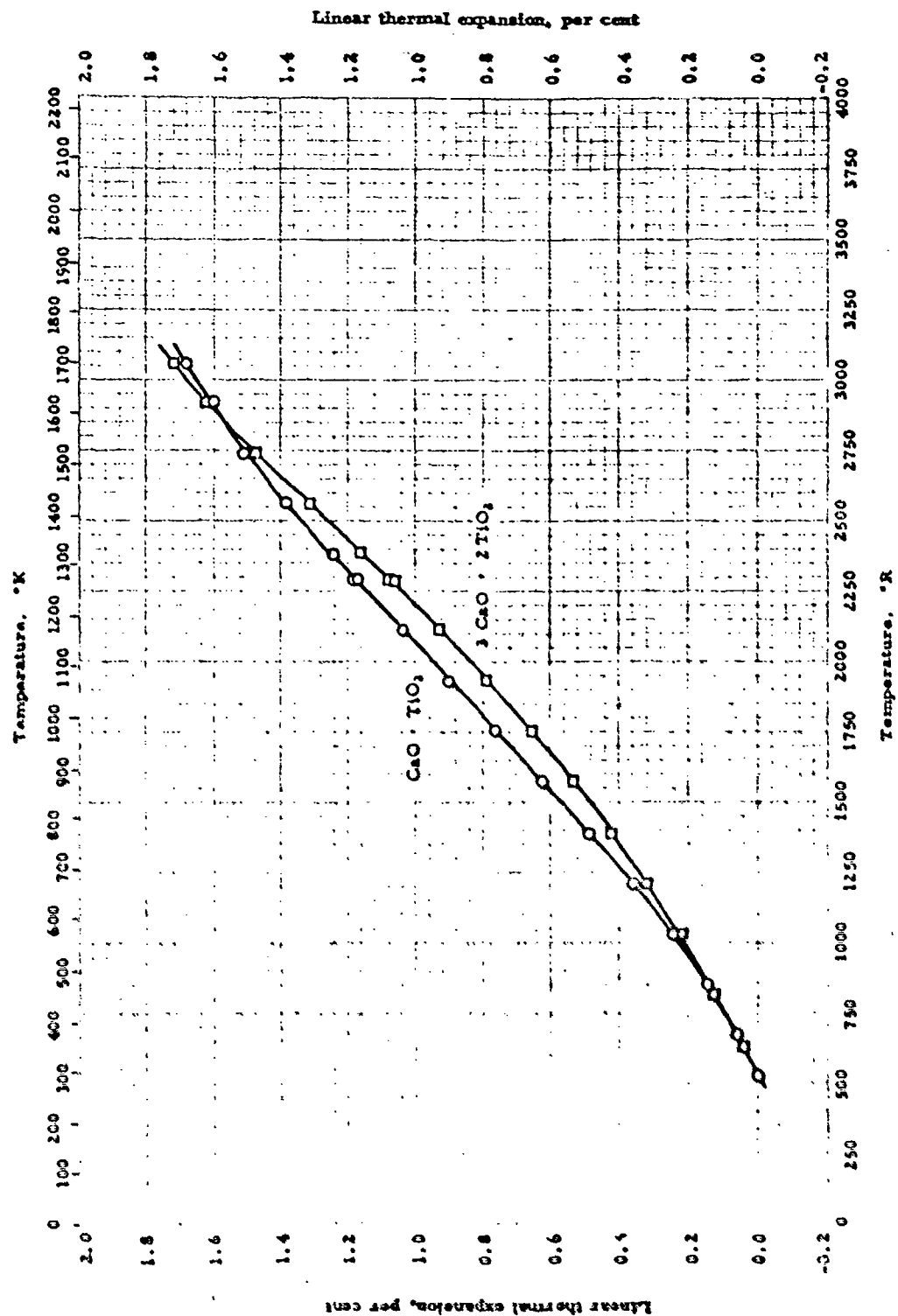
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	54-69	572-1730	Calcium titanate	Comparative; rods	Tested in vac.

60-695

WADC TR 58-476

582

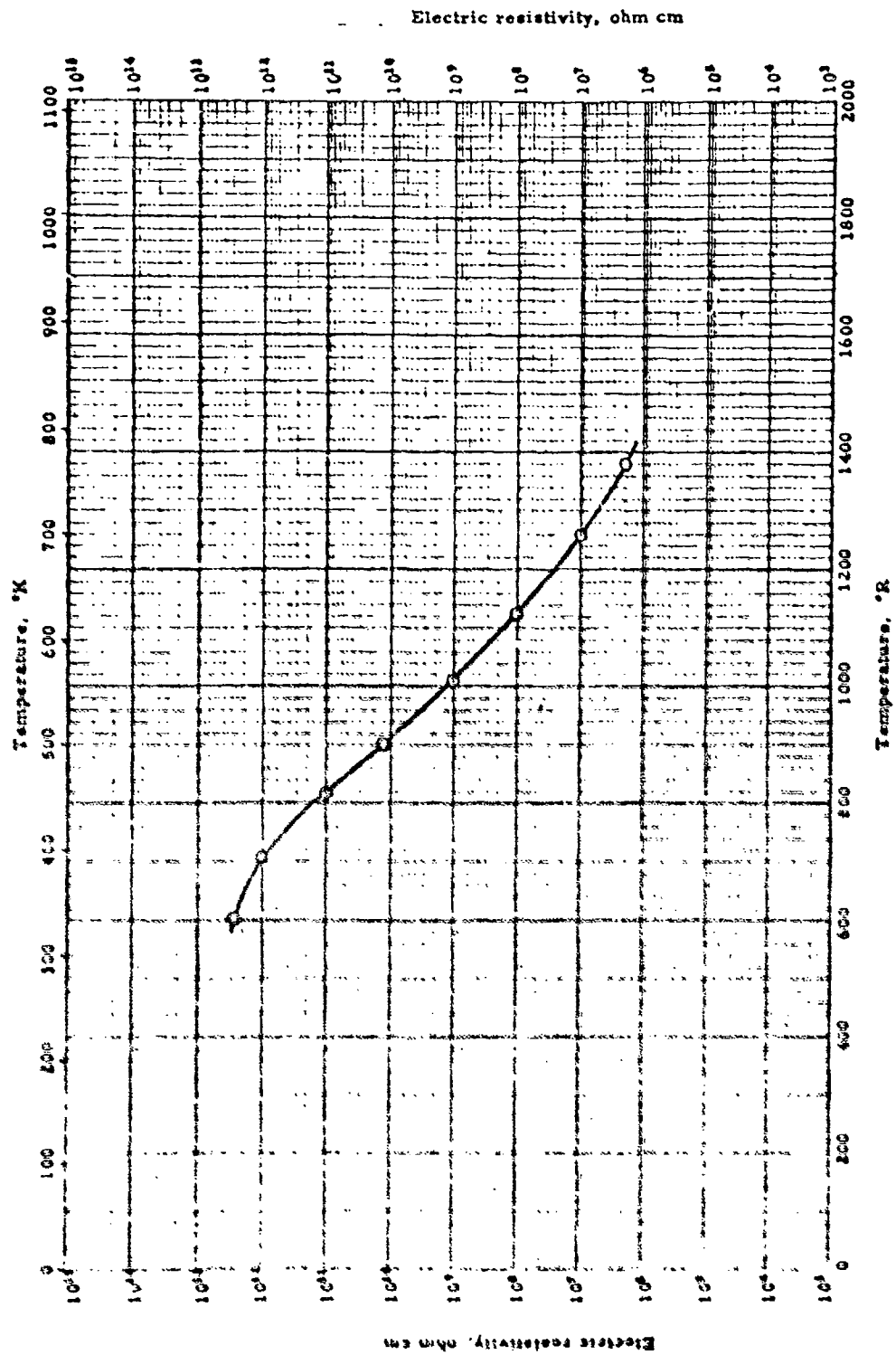


LINEAR THERMAL EXPANSION -- CALCIUM TITANATE

LINEAR THERMAL EXPANSION -- CALCIUM TITANATE

REFERENCE INFORMATION

Sym- bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Eichelberger, R. L.	54-146	572-3057	CaO · TiO ₂ , calcium metatitanate	Two methods: a. below 1000°C, interferometer b. above 1000°C, dilatometer	Pressed, fired to 1600°C
□	Edl.	54-146	672-3057	3CaO · 2TiO ₂	Same as above	Same as above



ELECTRIC RESISTIVITY -- CALCIUM TITANATE

ELECTRIC RESISTIVITY -- CALCIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Ref. Range, °K	Material Composition	Test Method	Remarks
0	Weiss, E. K. and Andrews, M. C.	35-125 600-1100	CaTiO ₃	Potential drop, using vacuum tube electrometer	Temp. controlled to $\pm 0.1^\circ\text{C}$

PROPERTIES OF IRON TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point.	2750°R	1640°K
Heat of Fusion	257 Btu/lb _m	143 cal/g
Heat of Vaporisation. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
 0 2751 1640

Heat of Fusion: Btu/lb_m cal/g
 0 257 142.6

Heat of Vaporisation: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF IRON TITANATE

REFERENCE INFORMATION

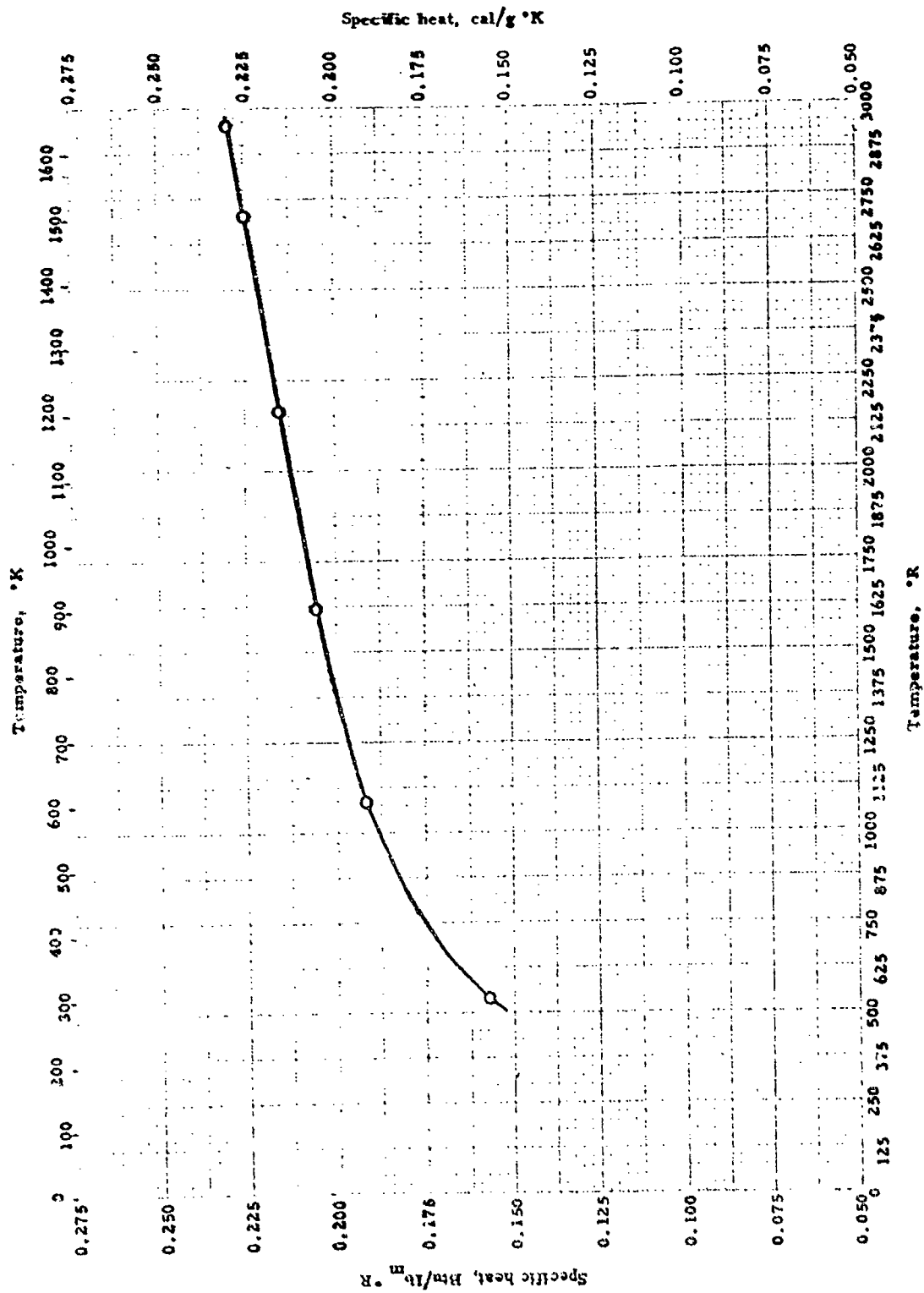
Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Maylor, B. F. and Cook, O. A.	6-3	1443	99.4% FeTiO ₃ , 0.6% SiO ₂ ; (Emasite)	MP: visual observation; calibrated Pt-Rh thermocouple ΔH: from enthalpy data above and below MP by drop method into copper calorimeter	Powdered ingredients mixed and heated in vacuum 30 hr. at 1165-1300°C

57-94

WADC TR 58-476

589

VII - B - 6 - g

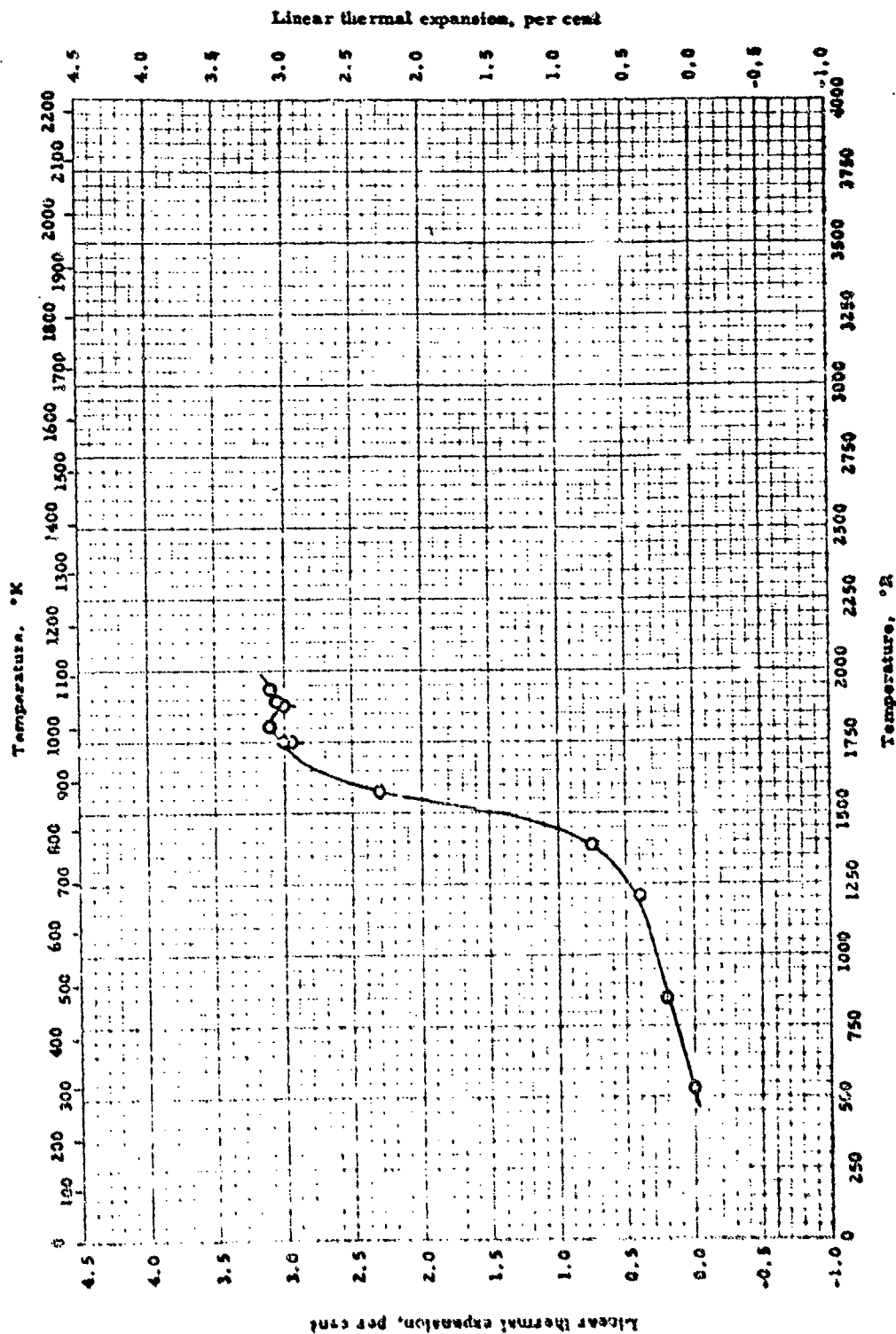


SPECIFIC HEAT -- IRON TITANATE

SPECIFIC R. - IRON TITANATE

REFERENCE INFORMATION

Sym Sol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Naylor, B. F., and Cook, O. A.	46-6	536-3240	Ilmenite; 99.4% FeTiO_3 ; 0.6% silica	Drop method; copper block calorimeter	Powdered raw materials mixed and heated in vacuum 30 hr. at 1165-1300°C

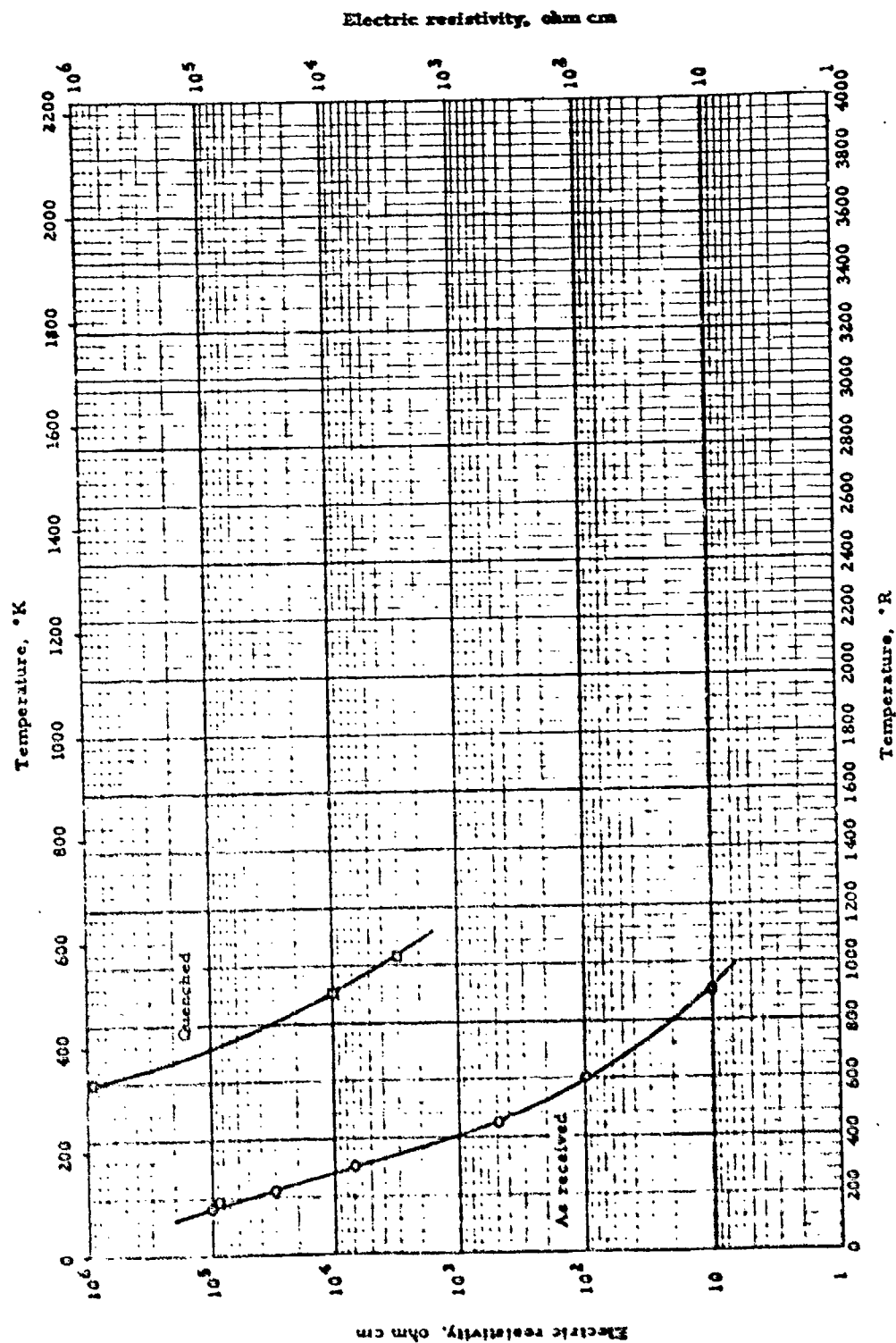


LINEAR THERMAL EXPANSION -- IRON TITANATE

LINEAR THERMAL EXPANSION -- IRON TITANATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Ishikawa, Y. and Sawada, S.	56-19	570-1932	Latent Prepared by $\text{Fe}_2\text{O}_3 + 3\text{TiO}_2 + \text{Fe} =$ 3FeTiO_3 ; final mol ratio $\text{Fe}:\text{Ti} =$ 0.9945:1	Dilatometer	O - heating, 2°C/sec.; O - cooling; powders milled, pressed, sintered 6 hr. at 1350°C in vacuum



59-1058

WADC TR 58-476

593

VII - B - 6 - g

ELECTRIC RESISTIVITY -- IRON TITANATE

ELECTRIC RESISTIVITY -- IRON TITANATE

REFERENCE INFORMATION

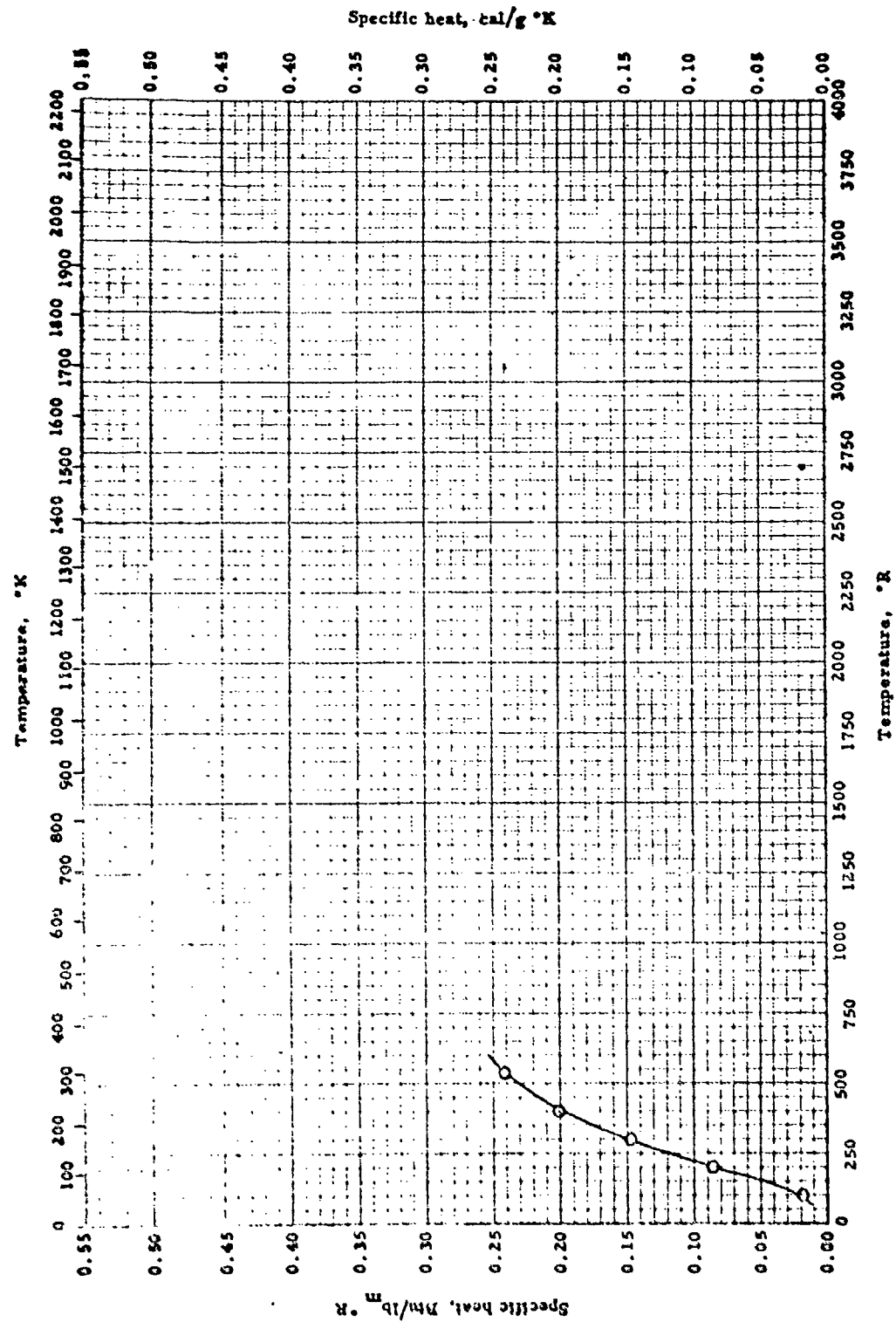
$\frac{\rho}{\text{cm}}$	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Ishikawa, Y. and Sawada, S.	56-19	164-1800	FeTiO ₃ , Imenite. Actual ratio Fe to Ti = 0.9945:1	Potential drop	Auth. gives $\rho = \rho_0 e^{\frac{E}{kT}}$ Measured in air and in vacuum
□	D14.	56-19	514-1092	Same as above	Same as above	Quenched, Meas. in vacuum

59-93

WADC TR 58-476

595

VII - B - 6 - h



SPECIFIC HEAT -- LITHIUM METATITANATE

SPECIFIC HEAT -- LITHIUM METATITANATE

REFERENCE INFORMATION

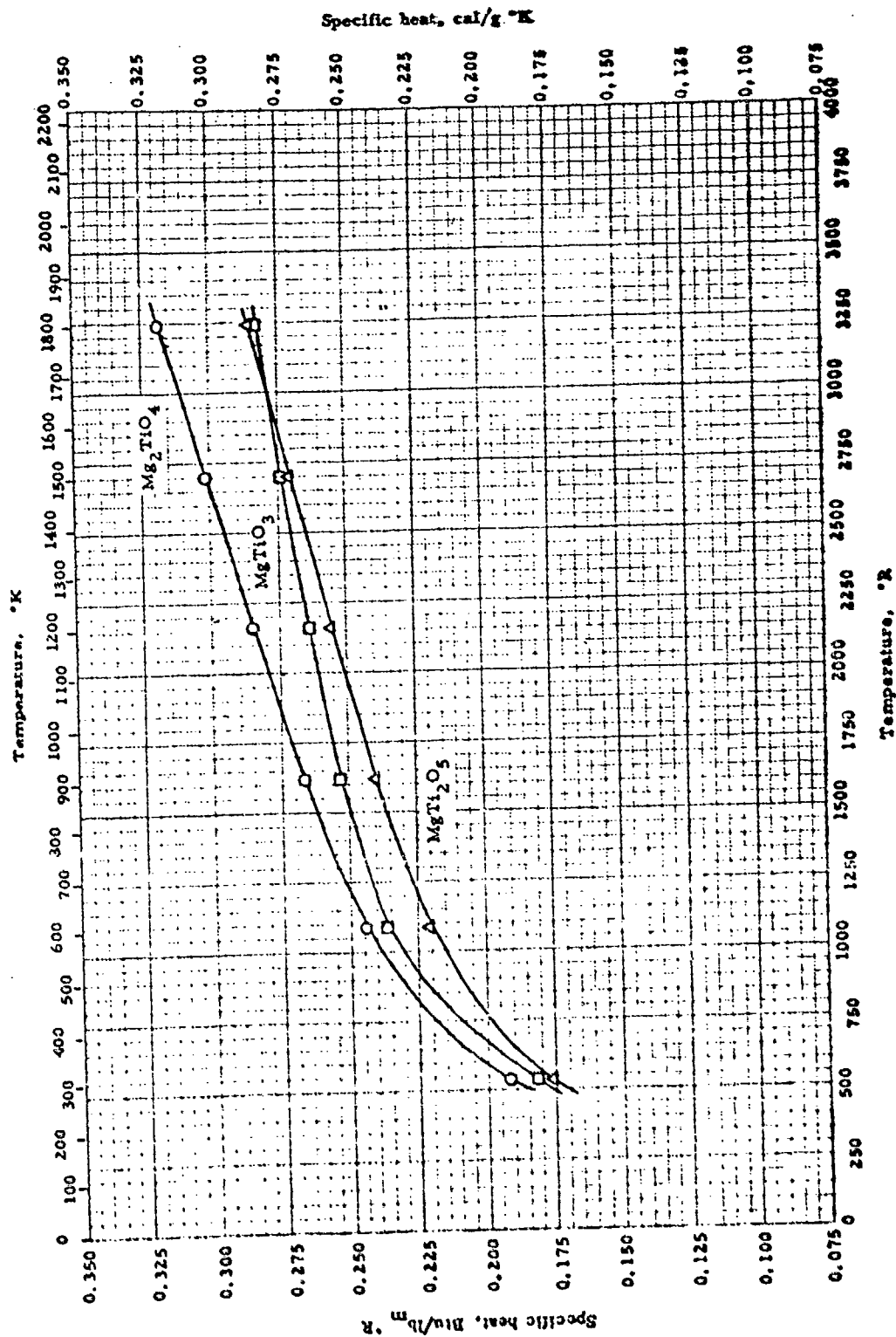
Syn No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	55-42	99-537	Li ₂ TiO ₃ , 72.70% titania (cf. theor. 72.78%); 0.06% Ni + Pt; 0.03% silica	Guarded sample	

59-919

WADC TR 58-476

597

VII - B - 6 - J

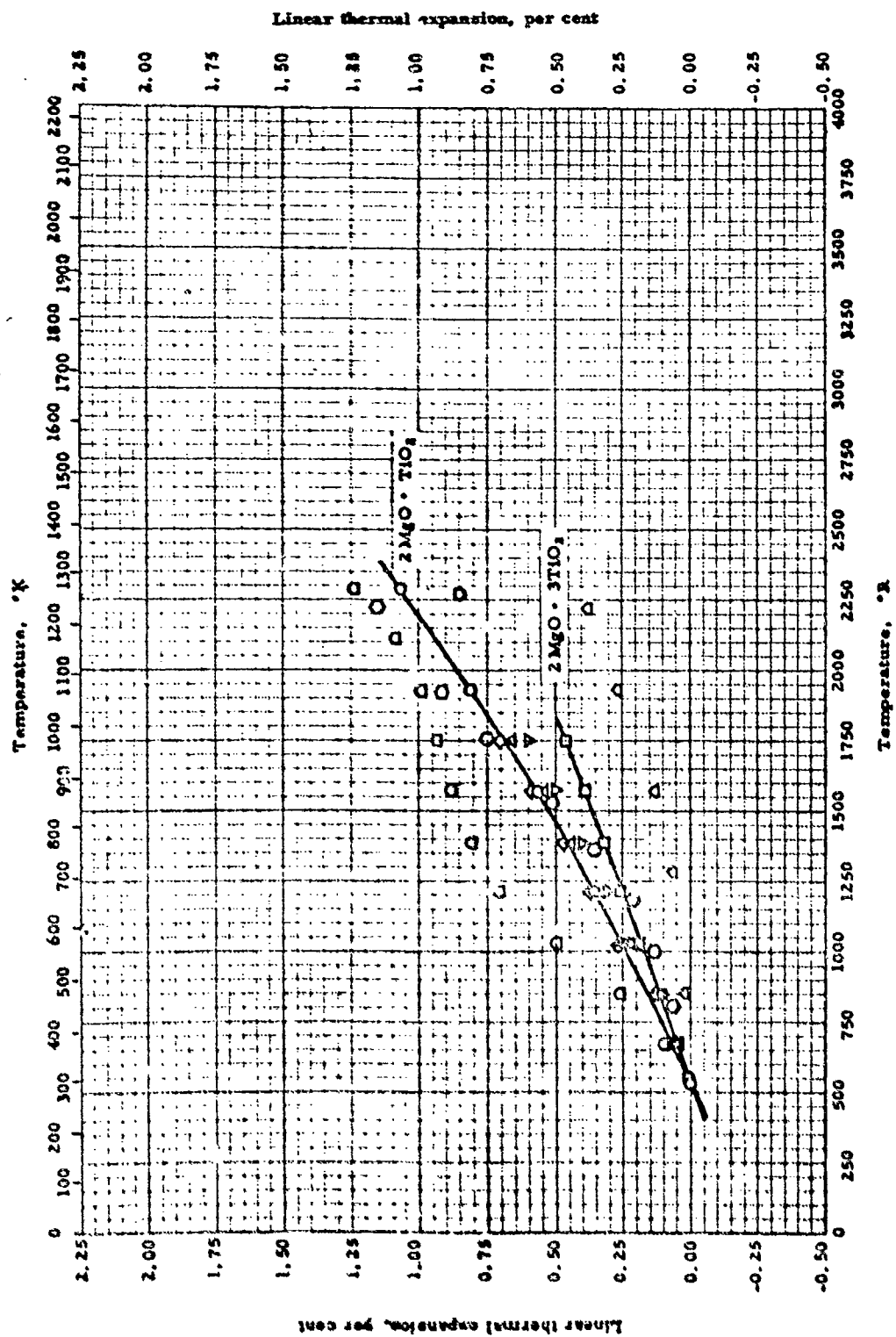


SPECIFIC HEAT -- MAGNESIUM TITANATE

SPECIFIC HEAT -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Orr, R. L. and Coughlin, J. P.	52-61	536-3240	Mg ₂ TiO ₄ , 49.53% TiO ₂ (cf. theor. 49.77%); 0.41% SiO ₂	Drop method; copper block calorimeter	Oxides were mixed, pressed at 15,000 psi, and heated for long periods at 1300 - 1500 °C. Auth. est. accuracy of heat content data 0.5%
Δ	Wid.	52-61	536-3240	Mg ₂ Ti ₂ O ₅ , 79.63% TiO ₂ (cf. theor. 79.85%); 0.16% TiO ₃	Same as above	Same as above
□	Naylor, B. F. and Cobalt, G. A.	46-6	536-3240	99% MgTiO ₃ , c. 45% MgO	Drop method; copper block calorimeter	

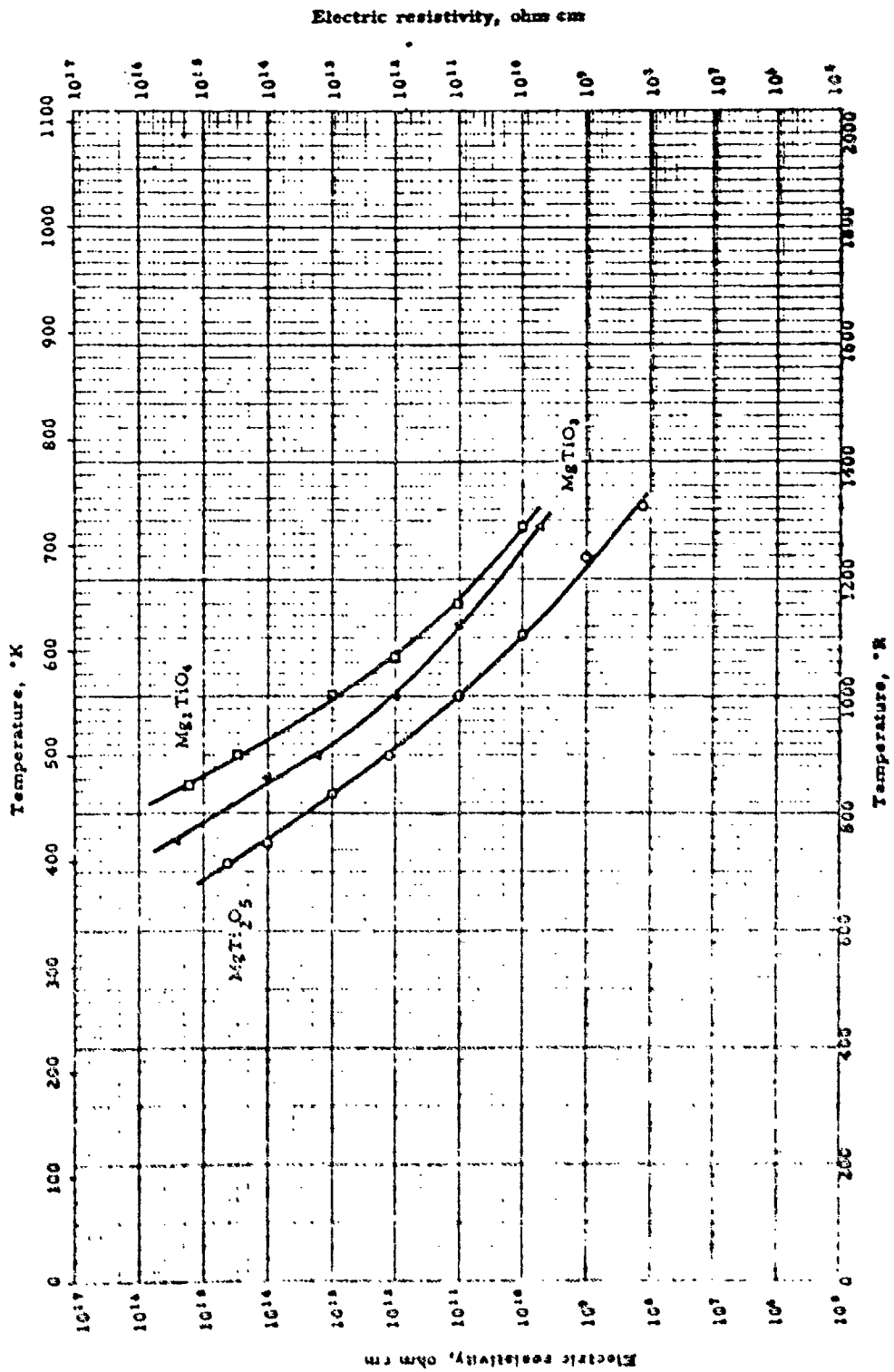


LINEAR THERMAL EXPANSION -- MAGNESIUM TITANATE

LINEAR THERMAL EXPANSION -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McKlastry, H. A., Hoeker, C. F. et al.	49-15	528-2292	50.2% MgO; 49.8% TiO ₂ (2MgO · TiO ₂)	Not given	Fired 2 hr. at 1400°C
△	Shelton, G. R., Creamer, A. S. and Bunting, E. H.	48-3	672-1752	50.2% TiO ₂ ; 49.8% MgO (2MgO · TiO ₂)	Interferometer	Heated 12 hr. at 1100°C, matured 5 hr. at 1250- 1450°C
◇	Ibid.	48-3	672-1752	66.5% TiO ₂ ; 33.5% MgO (MgO · TiO ₂)	Same as above	Same as above
□	Ibid.	48-3	672-1752	74.8% TiO ₂ ; 25.2% MgO (2MgO · 3TiO ₂)	Same as above	Same as above
▽	Ibid.	48-3	672-1752	90.8% TiO ₂ ; 9.2% MgO (MgO · 5TiO ₂)	Same as above	Same as above
○	Buessem, W. R., Earhart, W. R. et al.	52-133	582-2220	Magnesium dititanate	Unit cell meas. by x-ray diffraction	Meas. along a axis of crys- tal
○	Ibid.	52-133	555-2292	Same as above	Same as above	Meas. along b axis of crys- tal
○	Ibid.	52-133	615-2220	Same as above	Same as above	Meas. along c axis of crys- tal
○	Ibid.	52-133	537-2256	Same as above	Same as above	Random



ELECTRIC RESISTIVITY -- MAGNESIUM TITANATE

ELECTRIC RESISTIVITY -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
□	Weise, E. K. and Andrews, M. C.	56-152	717-1323	MgTi ₂ O ₃	Potential drop with vacuum tube electrometer	
□	D.M.	56-152	853-1290	Mg ₂ TiO ₄	Same as above	
△	End.	56-152	750-1250	MgTiO ₃	Same as above	

60-664

WADC DA 58-476

602

PROPERTIES OF STRONTIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	~186°E	2328°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft^3 g/cm^3

Melting Point: °R °K

○	4182	2323
□	4128 ± 36	2293 ± 20
△	4164 ± 36	2313 ± 20
◇	3084 ± 18	1713 ± 10
▽	3732 ± 36	2073 ± 20
○	3624	2013

Heat of Fusion: Btu/lb_m cal/g

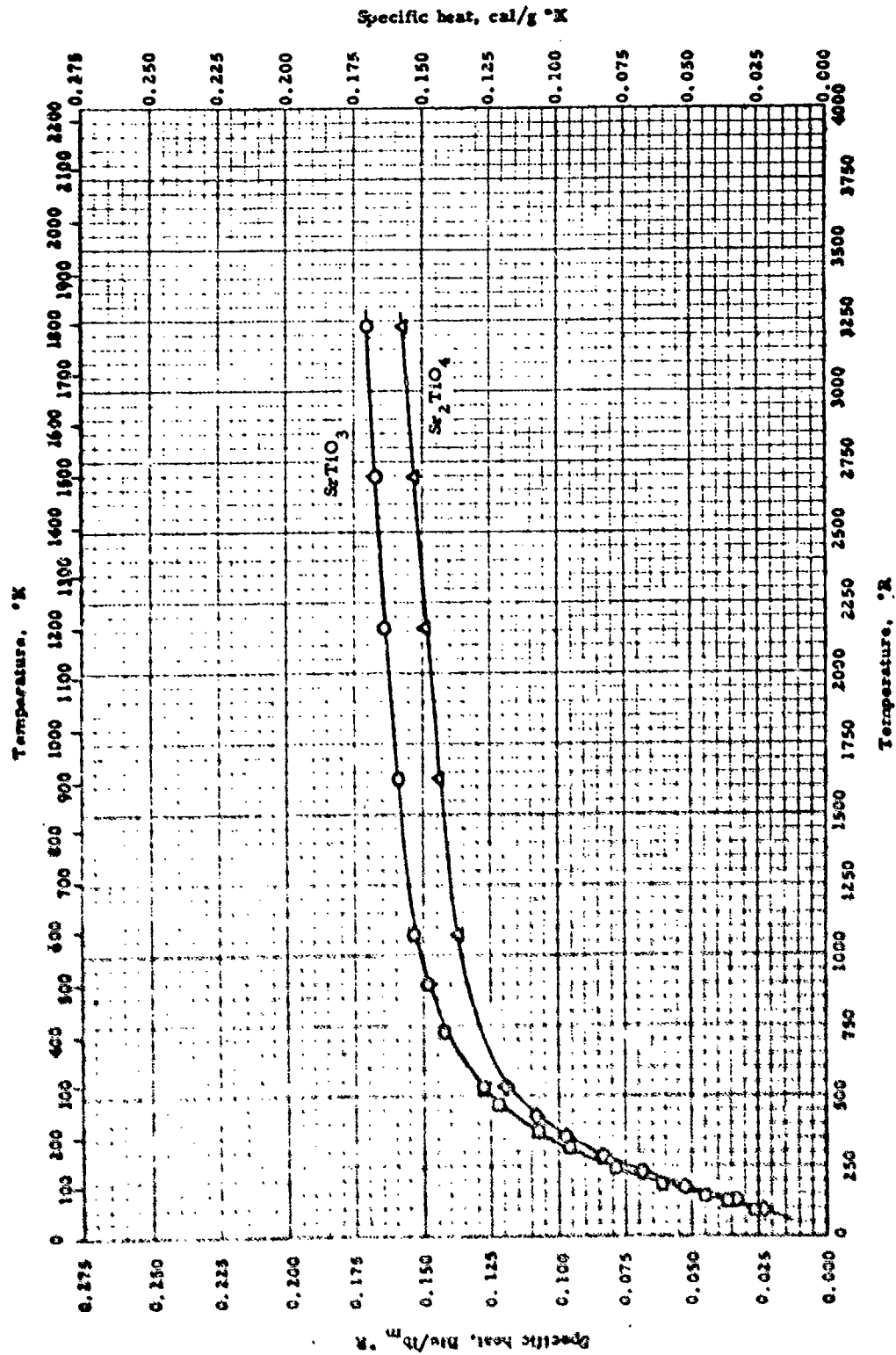
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF STRONTIUM TITANATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °C	Material Composition	Test Method	Remarks
57-82	Dasgupta, J. A. and De Vries, E. C.	57-82	4182	SrTiO ₃	MP: 3 methods: (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouples (3) visual with optical pyrometer	Preintered at 1100°C; sintered at 1350-1500°C
55-74	Trasbikowski, W. and Drye, M.	55-74	4092-4161	SrTiO ₃	MP: visual observation; optical pyrometer	Same as above
57-82	Drye, M. and Trasbikowski, W.	57-82	4123-4200	SrTiO ₃	MP: not given	Same as above
55-74	Trasbikowski, W. and Drye, M.	55-74	3246-4002	Eutectic between TiO ₂ and SrTiO ₃ containing 70-80% TiO ₂	MP: visual observation; optical pyrometer	Preintered at 1100°C; sintered at 1350-1500°C
55-74	Idid.	55-74	3696-3768	25SrO + TiO ₂	MP: same as above	Same as above
55-74	Idid.	55-74	3624	Eutectic of 27SrO - TiO ₂ and SrO; 20-30% mole of TiO ₂	MP: same as above	Same as above



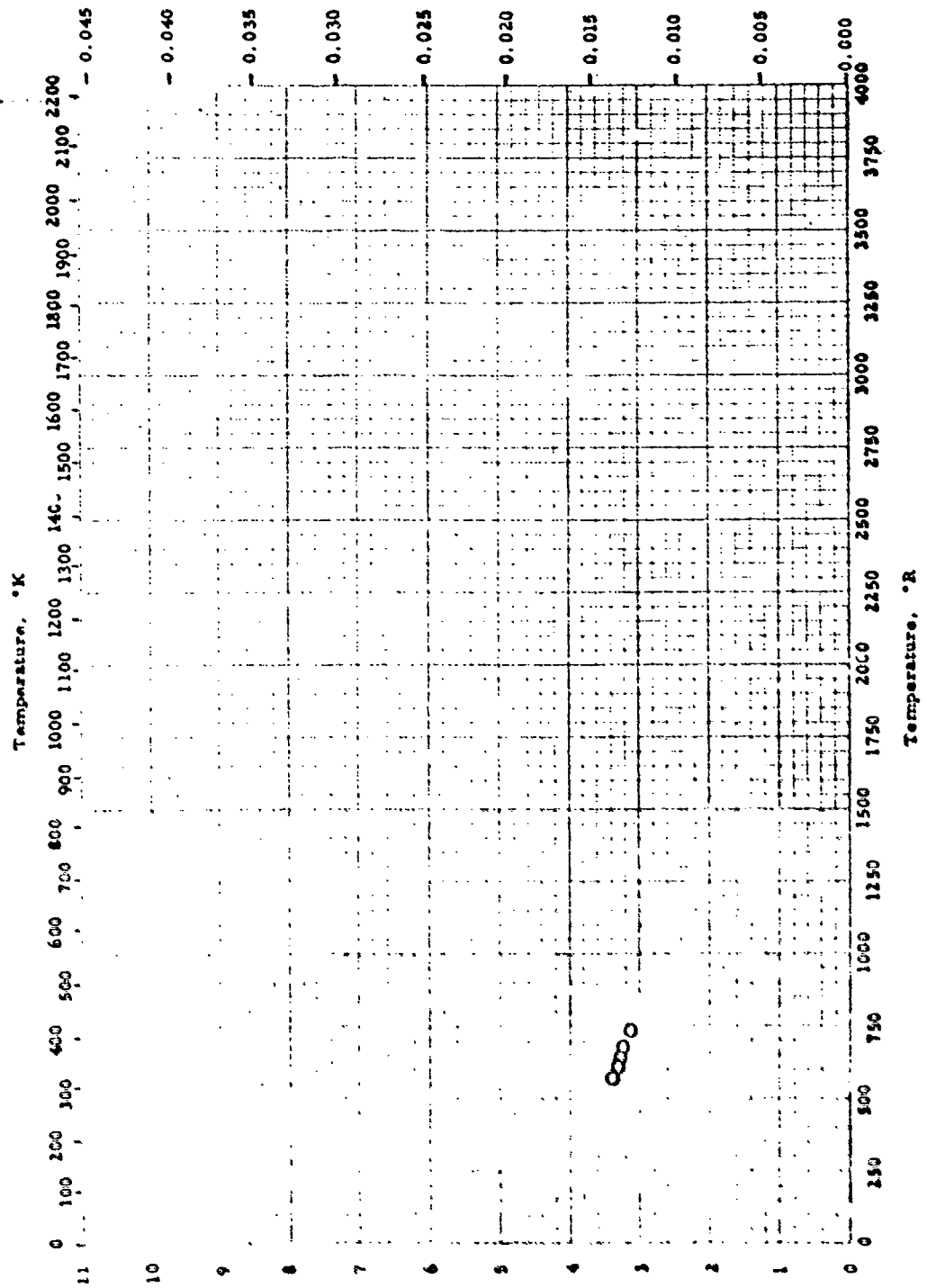
SPECIFIC HEAT -- STRONTIUM TITANATE

SPECIFIC HEAT -- STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Coughlin, J. P. and Orr, R. L.	53-13	692-3297	Strontium metatitanate, SrTiO_3 · 99.5% pure	Drop method; copper block calorimeter	Prepared from reagent grade Sr carbonate and titania by prolonged heating at 1350°C
□	Todd, S. S. and Lorensen, R. E.	52-13	99-537	Strontium metatitanate, SrTiO_3 · 99.5% pure	Guarded sample	Prepared from reagent grade Sr carbonate and titania by prolonged heating at 1350°C
△	Coughlin, J. D. and Orr, R. L.	53-13	706-3769	Strontium orthotitanate, Sr_2TiO_4 · 99.5% pure; 0.17% CaO; 0.03% SiO_2 . Analyzed 27.85 at % TiO_2 (cf. theor. 27.82%)	Drop method; copper block calorimeter	
◇	Todd, S. S. and Lorensen, R. E.	52-59	97-527	Strontium orthotitanate, Sr_2TiO_4 · 99.5% pure; 0.17% CaO; 0.03% SiO_2 . Analyzed 27.85 at % TiO_2 (cf. theor. 27.82%)	Guarded sample	

Thermal conductivity, cal/sec cm °K

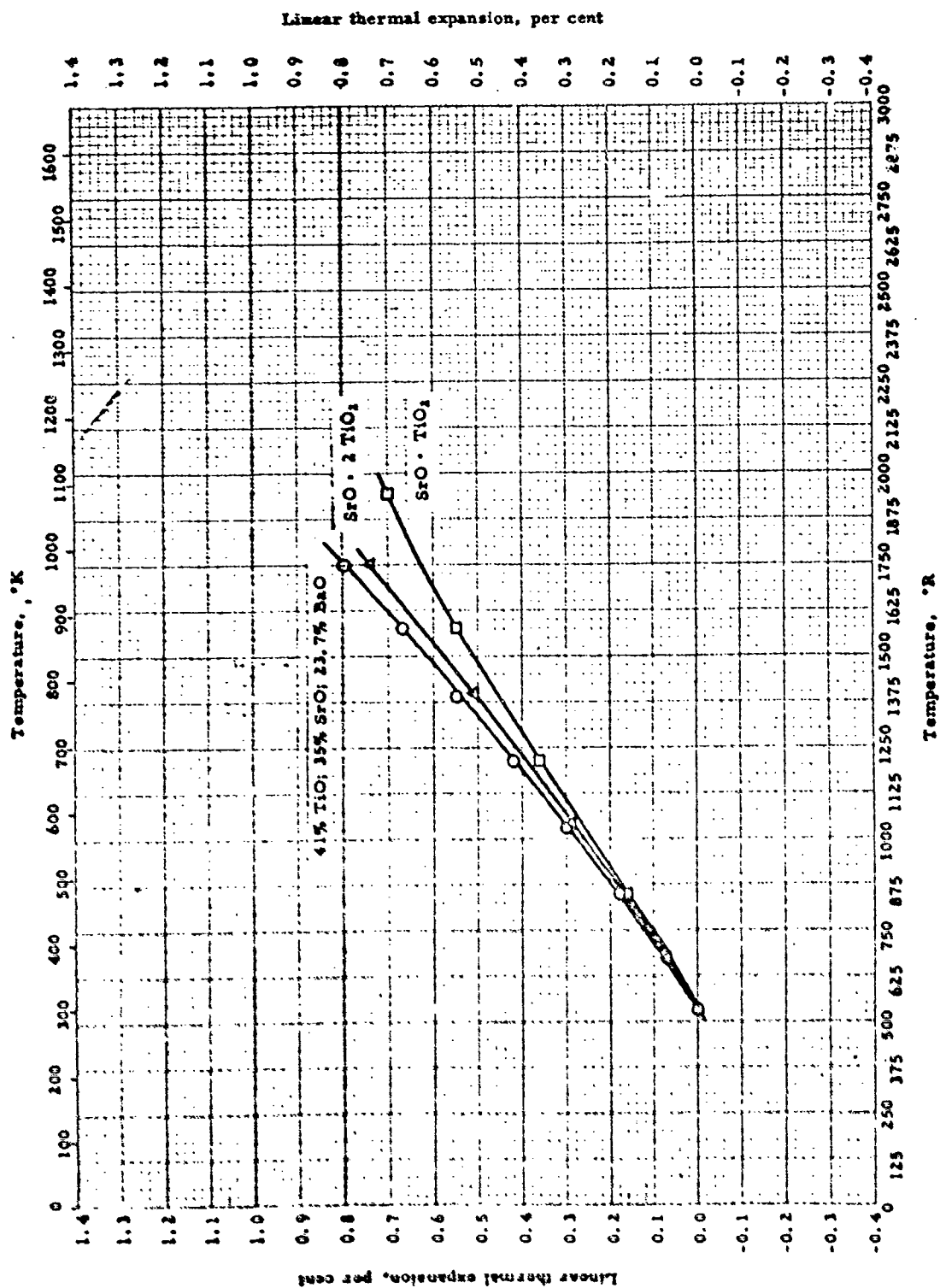


THERMAL CONDUCTIVITY -- STRONTIUM TITANATE

THERMAL CONDUCTIVITY -- STRONTIUM TITANATE

REFERENCE INFORMATION

Sym B31	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	54-69	569-738	Strontium titanate	Comparative: rods	Tested in vac.



60-693
WADC TR 58-476 609

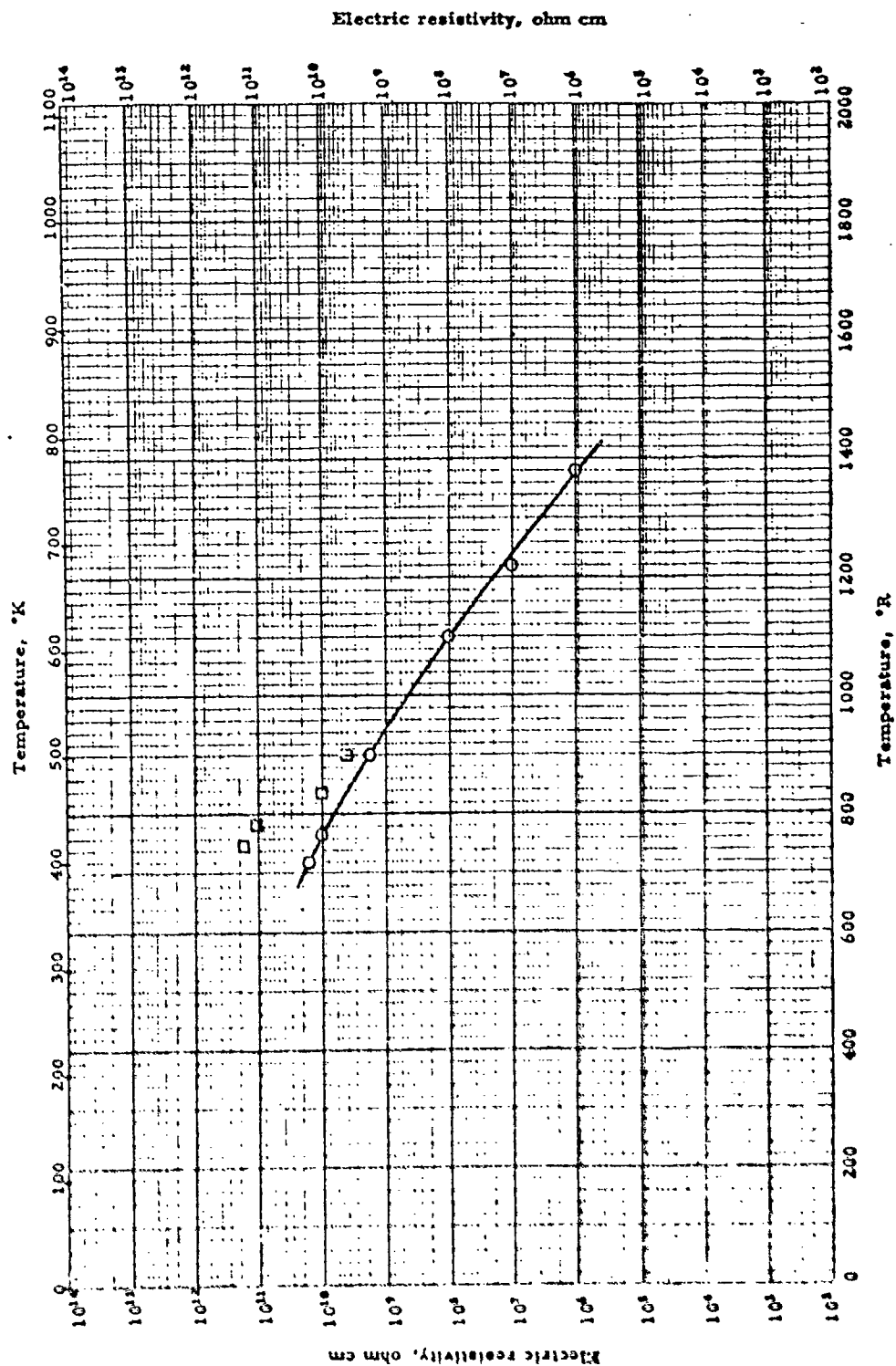
VII - B - 6 - k

LINEAR THERMAL EXPANSION -- STRONTIUM TITANATE

LINEAR THERMAL EXPANSION -- STRONTIUM TITANATE

REFERENCE INFORMATION

Sym Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bunning, E. N., Shelton, G. R. and Creamer, A. S.	47-9	672-1752	41.0% TiO ₂ ; 35.0% SrO; 23.7% BaO; prepared from 64% (SrO + TiO ₂); 36% (BaO + TiO ₂)	Interferometer	Heated 12 hr. at 1100°C, matured 6 hr. at 1250-1430 °C
□	Idid.	47-9	672-1752	60.7% TiO ₂ ; 39.3% SrO; (SrO · 2TiO ₂)	Same as above	Same as above
Δ	Idid.	47-9	672-1752	43.6% TiO ₂ ; 56.4% SrO; (SrO · TiO ₂)	Same as above	Same as above



ELECTRIC RESISTIVITY -- STRONTIUM TITANATE

ELECTRIC RESISTIVITY -- STRONTIUM TITANATE

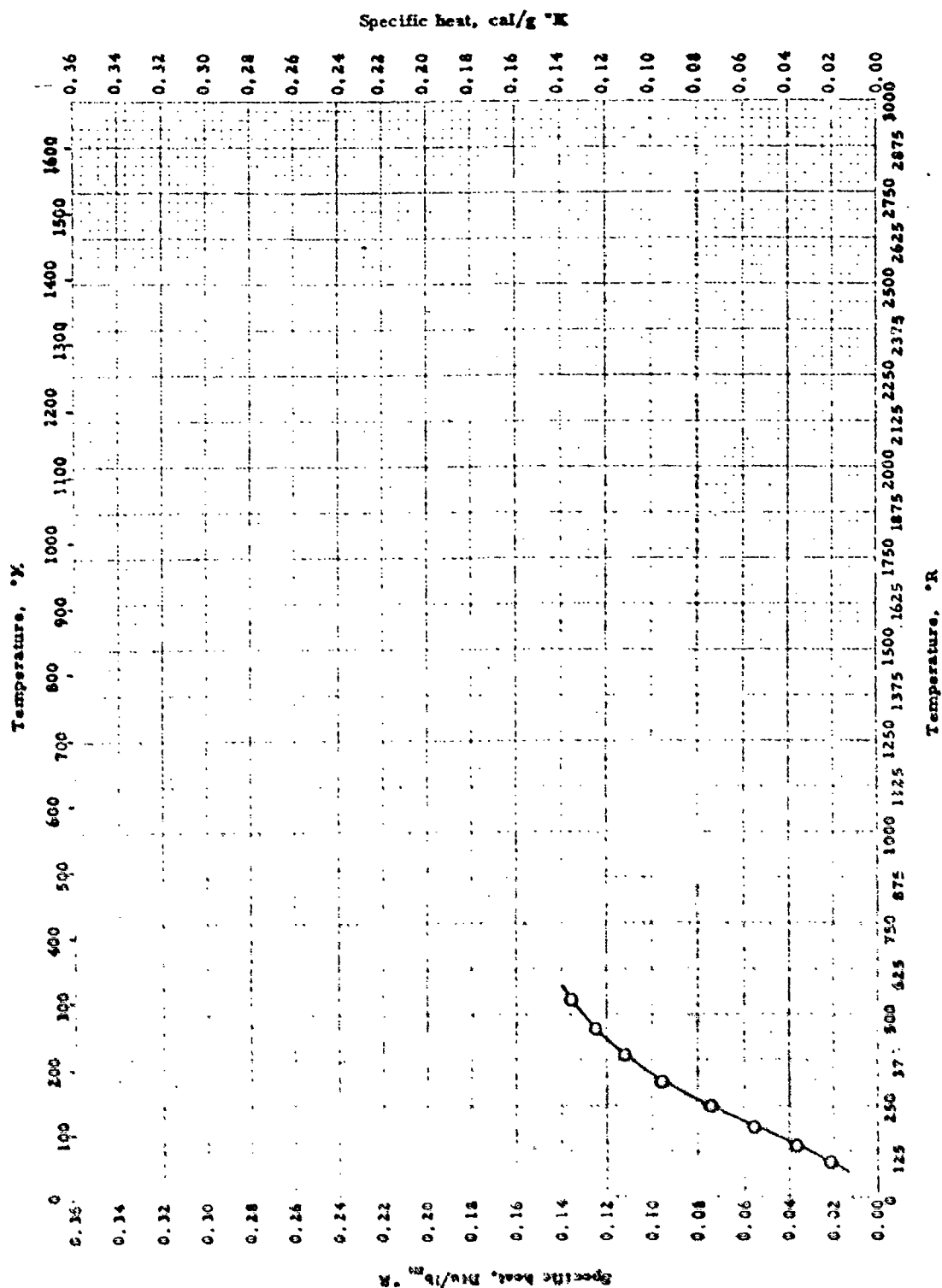
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Weise, E. K. and Andrews, M. C.	56-152	720-1380	SrTiO ₃	Potential drop, using vacuum tube electronics etc	Temp. controlled to $\pm 0.1^\circ\text{C}$ meas. in air
□	Ibid.	56-152	650-900	Same as above	Same as above	Temp. controlled to $\pm 0.1^\circ\text{C}$ meas. in O ₂

59-445

WADC TR 58-476

613



SPECIFIC HEAT -- ZINC ORTHOTITANATE

V11 - B - 6 - 11

SPECIFIC HEAT -- ZINC ORTHOTITANATE

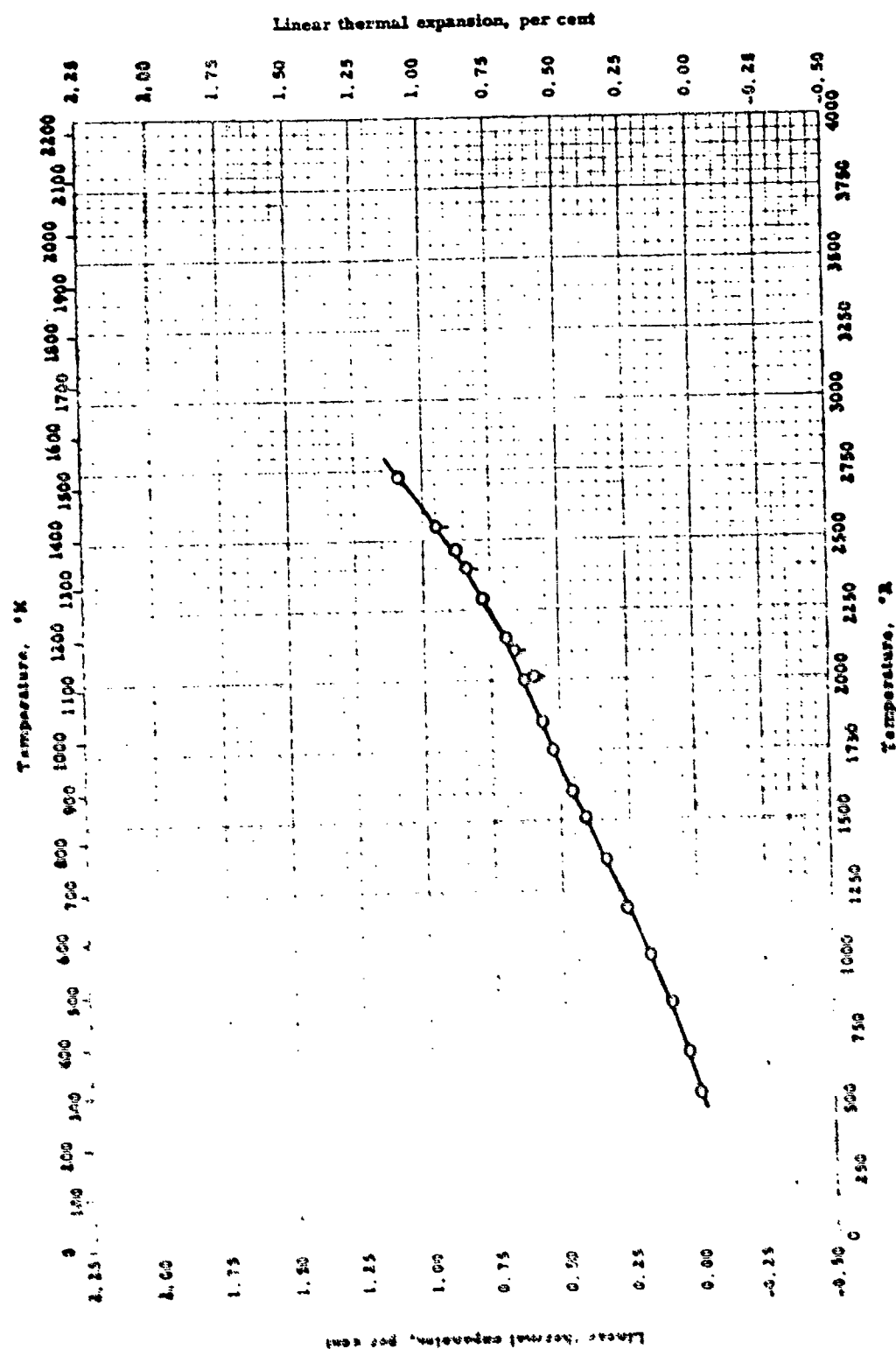
REFERENCE INFORMATION

O	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
	King, E. G.	55-42	97-517	Zn ₂ TiO ₄ • 67.08% ZnO; 32.86% TiO ₂ ; (cf. theor. 67.07% and 32.93%); 0.05% insoluble in HCl	Guarded sample	

69-272

WADC TR 58-476

615



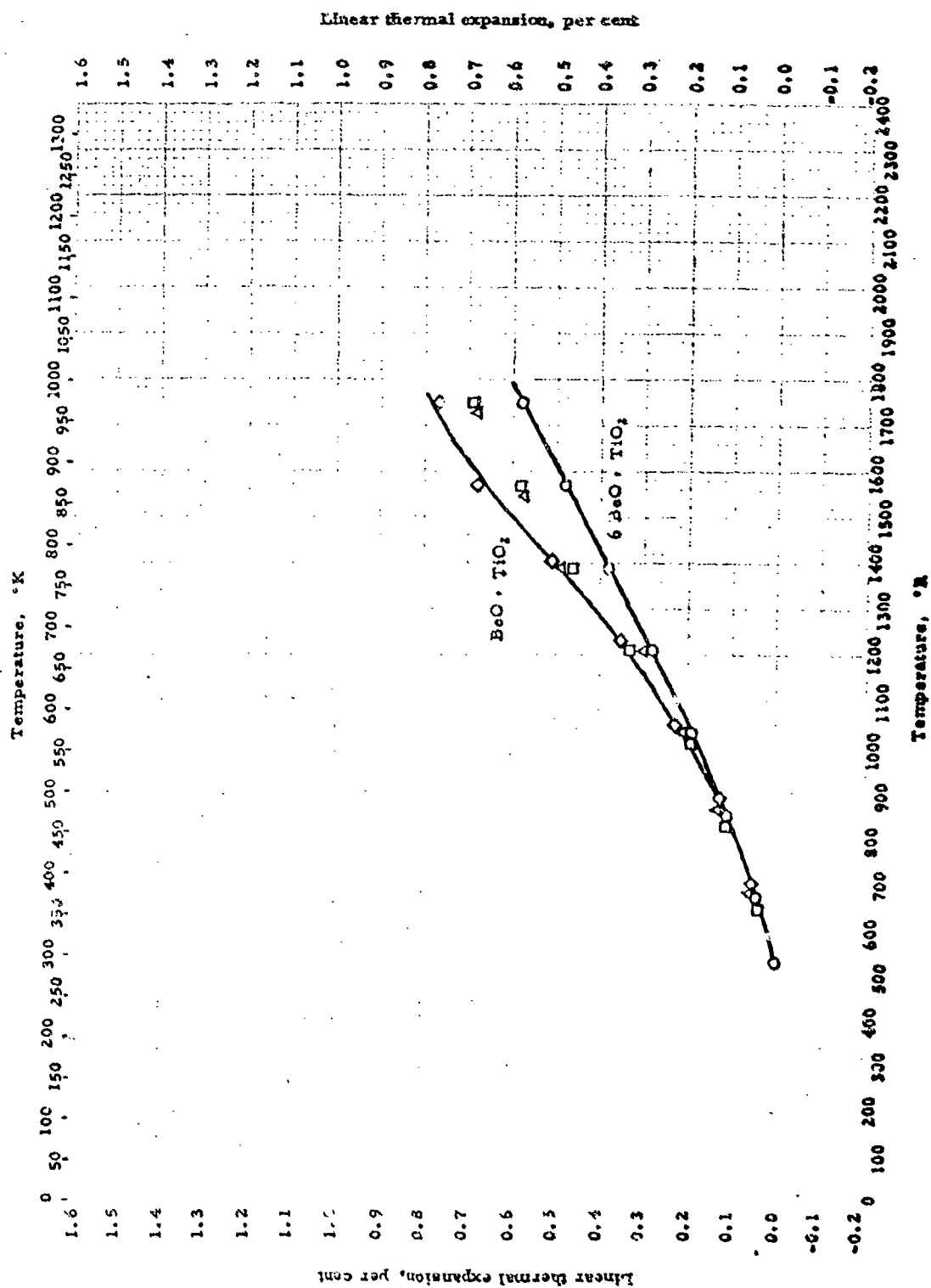
LINEAR THERMAL EXPANSION -- ZIRCONIUM TITANATE

VI - 2 - 6 - 1

LINEAR THERMAL EXPANSION -- ZIRCONIUM TITANATE

REFERENCE INFORMATION

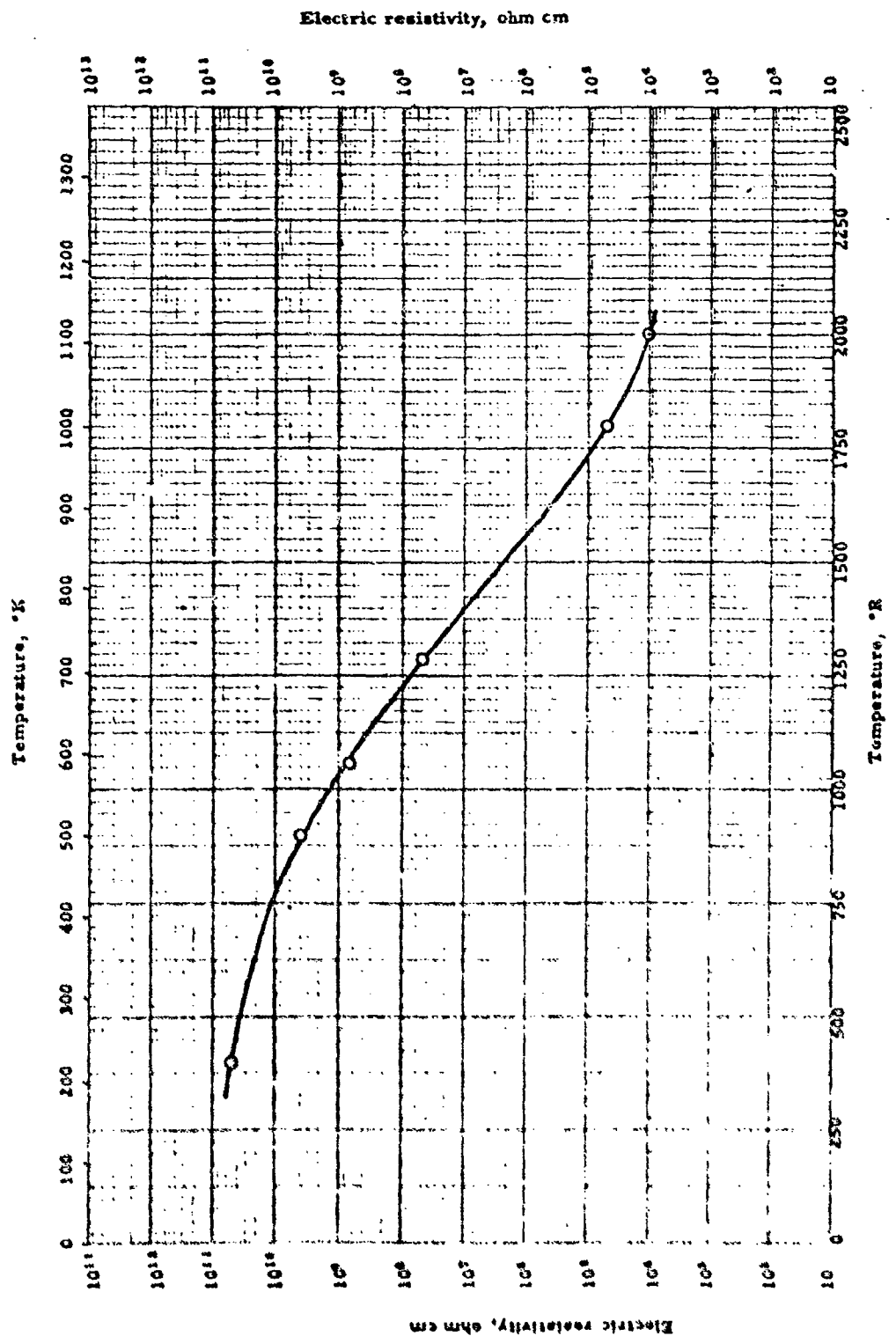
Diff. Co.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Mason, F. A. and Selig, L. H.	56-8 4280 57-62	442-2728	ZrTiO ₄	Dilatometer with differential transformer pickup	Quenched from 1400°C; Q - heating; Q - cooling



LINEAR THERMAL EXPANSION -- BERYLLIUM TITANATE

REFERENCE INFORMATION

Sym Ref	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Bunting, E. N, Shelton, G. R. et al.	51-86	537-1752	6BeO · TiO ₂	Interferometer	
□	Ibid.	51-86	537-1752	4BeO · TiO ₂	Same as above	
△	Ibid.	51-86	537-1752	2BeO · TiO ₂	Same as above	
◇	Ibid.	51-86	537-1752	BeO · TiO ₂	Same as above	



ELECTRIC RESISTIVITY -- NICKEL METATITANATE

ELECTRIC RESISTIVITY -- NICKEL METATITANATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Uchikawa, Y. and Sawada, S.	56-19	400-2000	NiTiO ₃	Potential drop	Stoichiometric mixture of NiO and TiO ₂ heated 3 hr. at 1350°C. Tested in air

60-494

WANG TR SA-476

820

PROPERTIES OF MAGNESIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	225 lb _m /ft ³	3.60 g/cm ³
Melting Point.	4320°R*	2400°K*
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	225 ± 0.6	3.60 ± 0.01

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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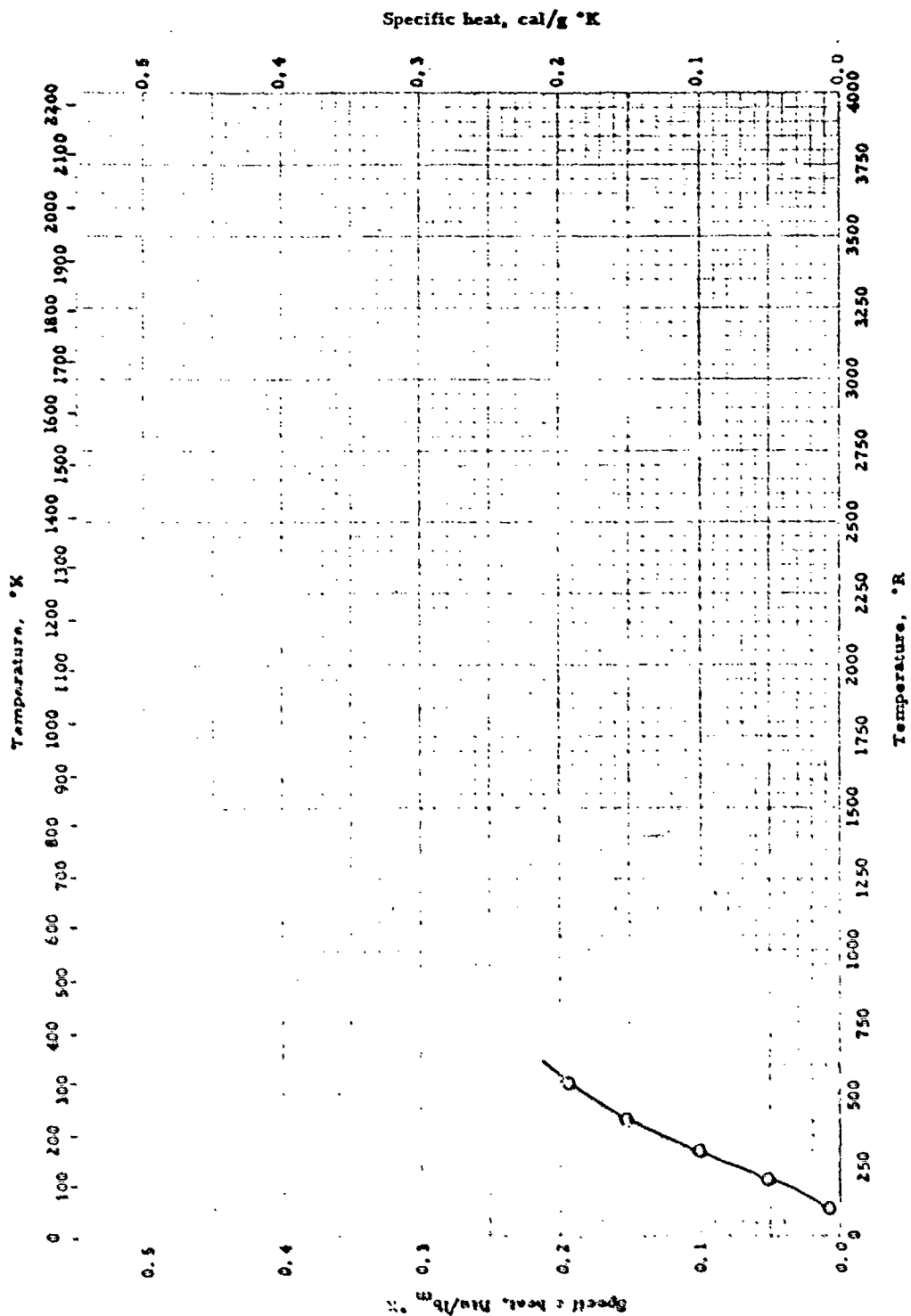
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Sym. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Oak Ridge National Laboratory	57-150	537	Spinel, magnesium aluminate	pt weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towne

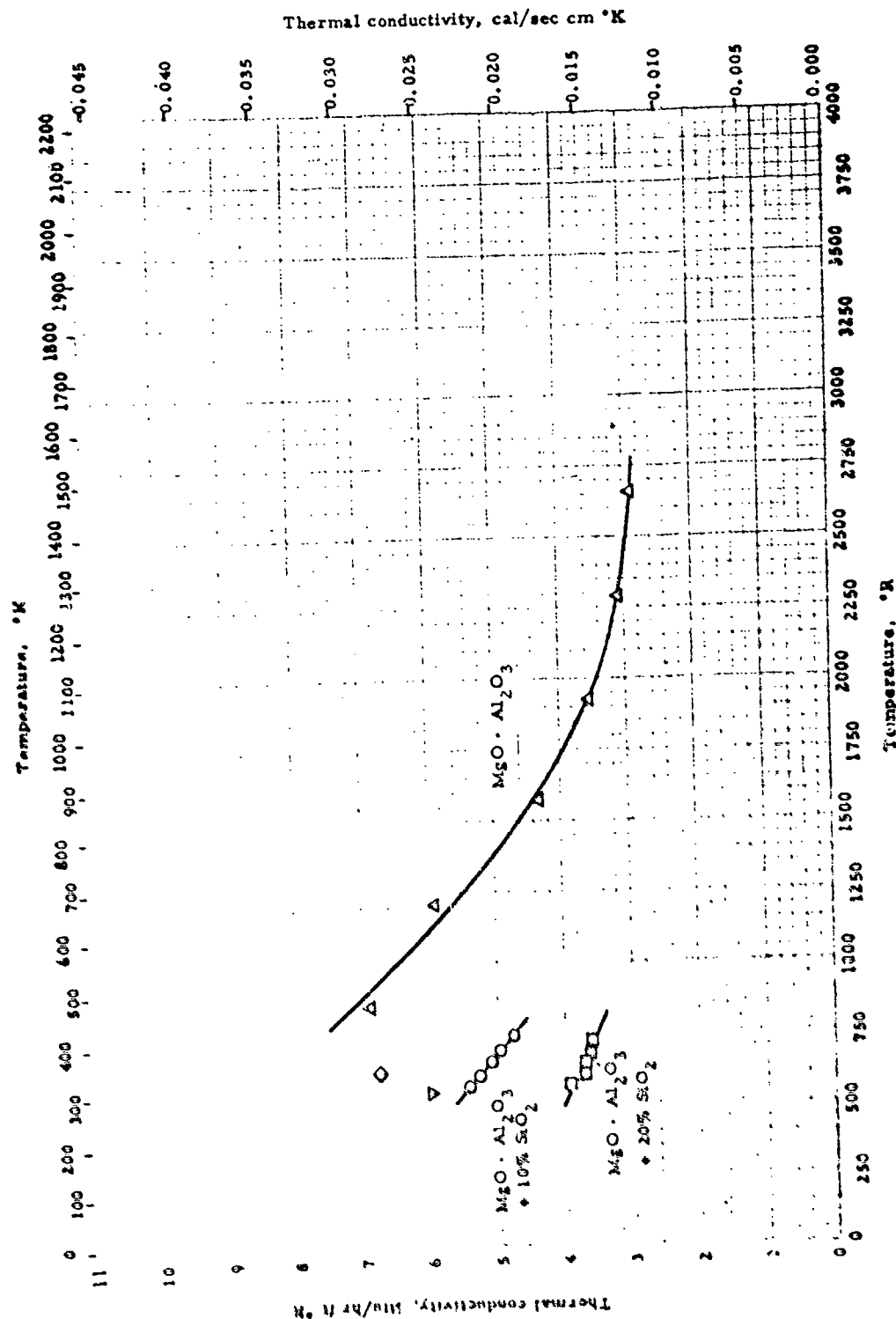


SPECIFIC HEAT -- MAGNESIUM ALUMINATE

SPECIFIC HEAT -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °E	Material Composition	Test Method	Remarks
O	King, E. G.	55-44	97-936	71.62% Al ₂ O ₃ (71.66% theoretical); 28.33% MgO (28.34% theoretical) (Spinel)	Guarded sample	



THERMAL CONDUCTIVITY -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

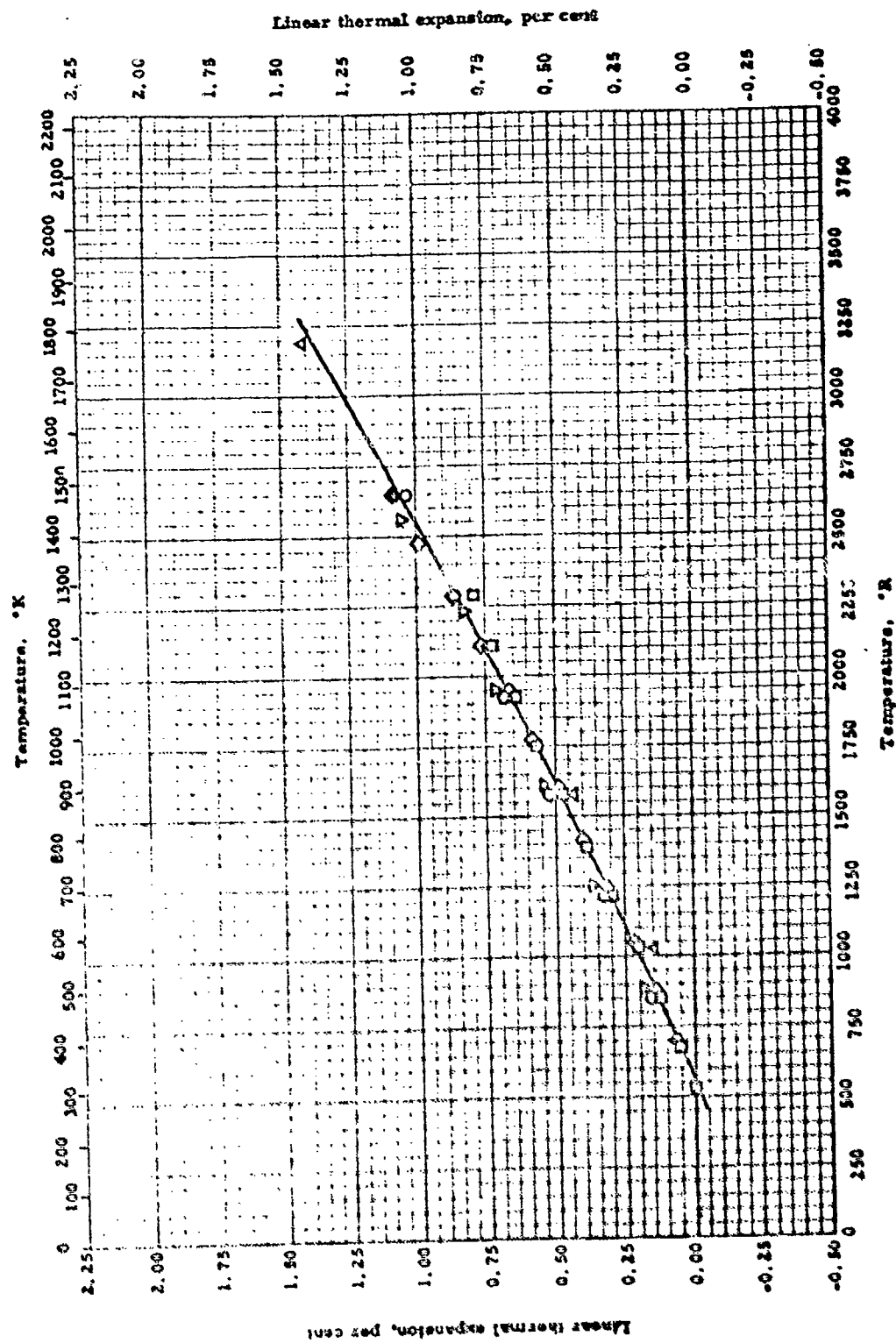
Ref.	Investigator	Ref.	Range, °R	Material: Composition	Test Method	Remarks
Q	New Jersey Ceramic Research Station	54-69	566-742	MgO · Al ₂ O ₃ + 10% SiO ₂	Comparative; rods	Tested in vacuum
Q	ibid.	54-69	570-721	MgO · Al ₂ O ₃ + 20% SiO ₂	Same as above	Same as above
Δ	Kingery, W. D. and Francis, T.	54-1	672-2192	MgO · Al ₂ O ₃ 71.9% Al ₂ O ₃ 29.0% MgO Bulk $\rho = 204 \text{ lb}_m/\text{ft}^3$ (cf theoretical 221); porosity 7.65%	Ellipsoidal envelope	
Q	Weeks, J. L. and Seifert, R. A.	53-17	618	Spinel; single crystal $\rho = 225 \text{ lb}_m/\text{ft}^3$	Comparative; Armco iron standard	Auth. est. accuracy + 20% Measured by O. Sieman, C. D. Bopp and R. L. Towns
V	Oak Ridge National Laboratory	57-15d	546	Spinel	Not described here, refers to others	

59-273

WADC TR 58-476

627

VII - B - 7 -

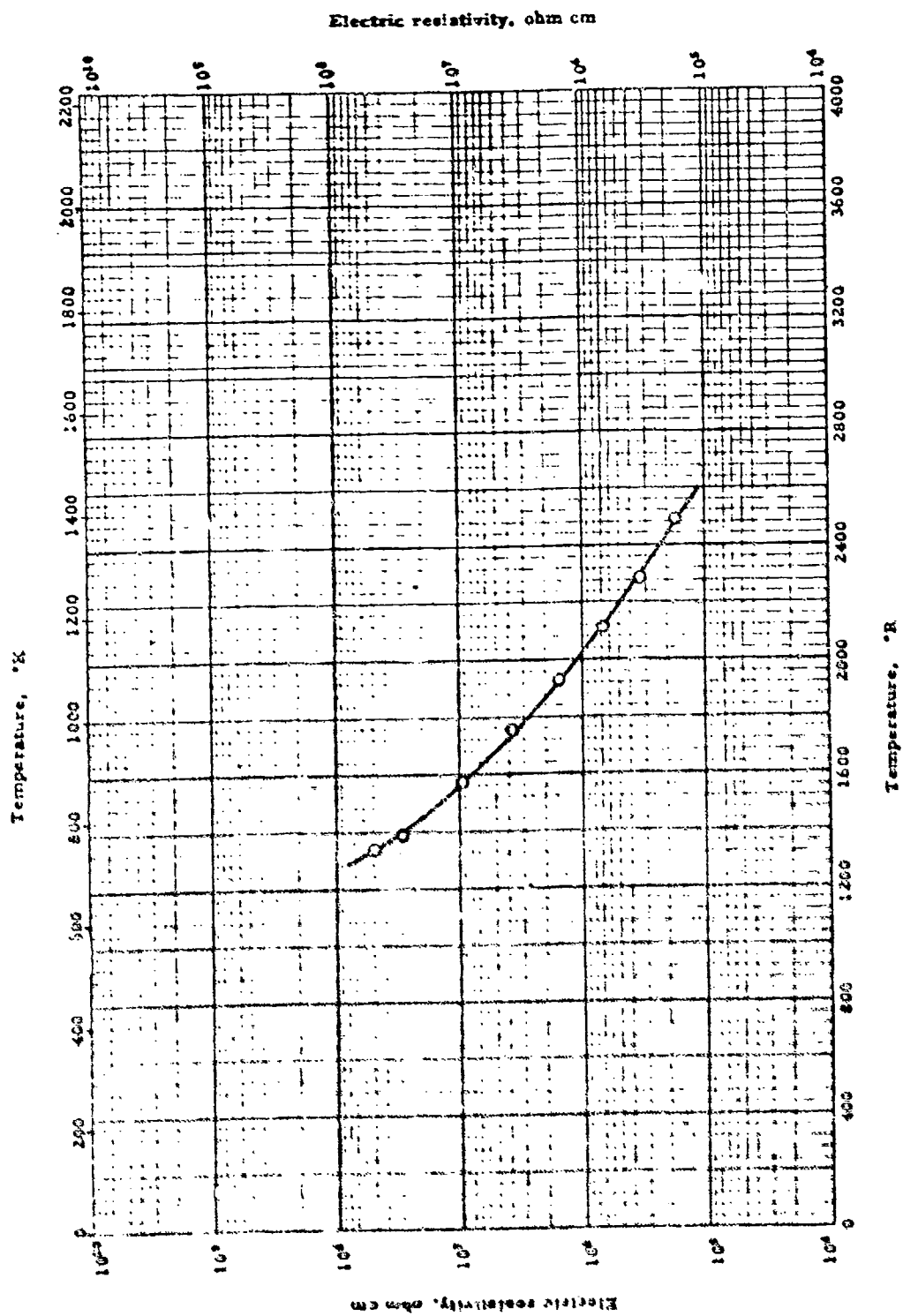


LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINATE

LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

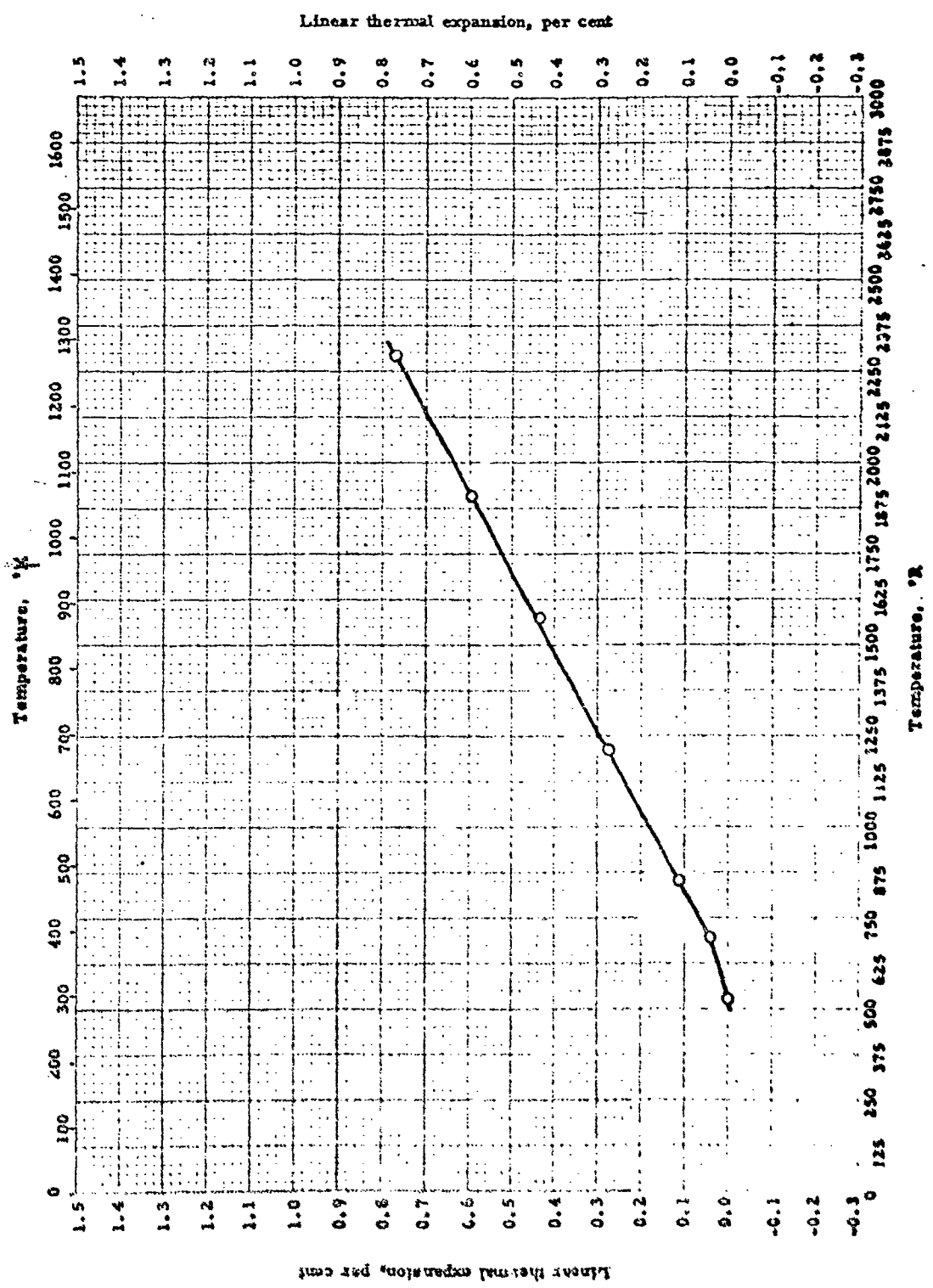
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beals, R. J. and Cook, R. L.	57-20	528-2652	Prepared from reagent grade materials	X-ray back reflection	Sample reacted with fused silica interferometer plates
□	Geller, R. P., Yavorski, P. J. et al.	46-4	528-2292	Prepared from 99+% Al_2O_3 ; 97% MgO (periclase)	Interferometer	
△	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Coarse fused grain, $MgO \cdot Al_2O_3$	Telemicroscopes sight- ing on pointed ends of sample Not given	Oxides mixed with 5% boric acid, molded, fired 2 hr. at 1530°C; crushed, molded, refired to 1530°C; repeated
◇	Zigby, G. R., Lovell, G. H. B. and Green, A. T.	46-8 also 43-15	672-2652	Spinel, $MgO \cdot Al_2O_3$ $p = 222 \text{ lb}/\text{in}^2$		
▽	Zimmerman, W. F. and Allen, A. W.	56-166	524-2620	$MgO \cdot Al_2O_3$	X-ray back reflection	



ELECTRIC RESISTIVITY -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °C	Material Composition	Test Method	Remarks
0	Rogers, H.	40-20	1229-2490	Spinel	Potential drop. Voltage by electrometer. Sample temp. by Pt-PtRh thermocouple	1 cm cube samples, platinized end faces. Auth. est. accuracy only order of magnitude



LINEAR THERMAL EXPANSION -- BARIUM ALUMINATE

LINEAR THERMAL EXPANSION -- BARIUM ALUMINATE

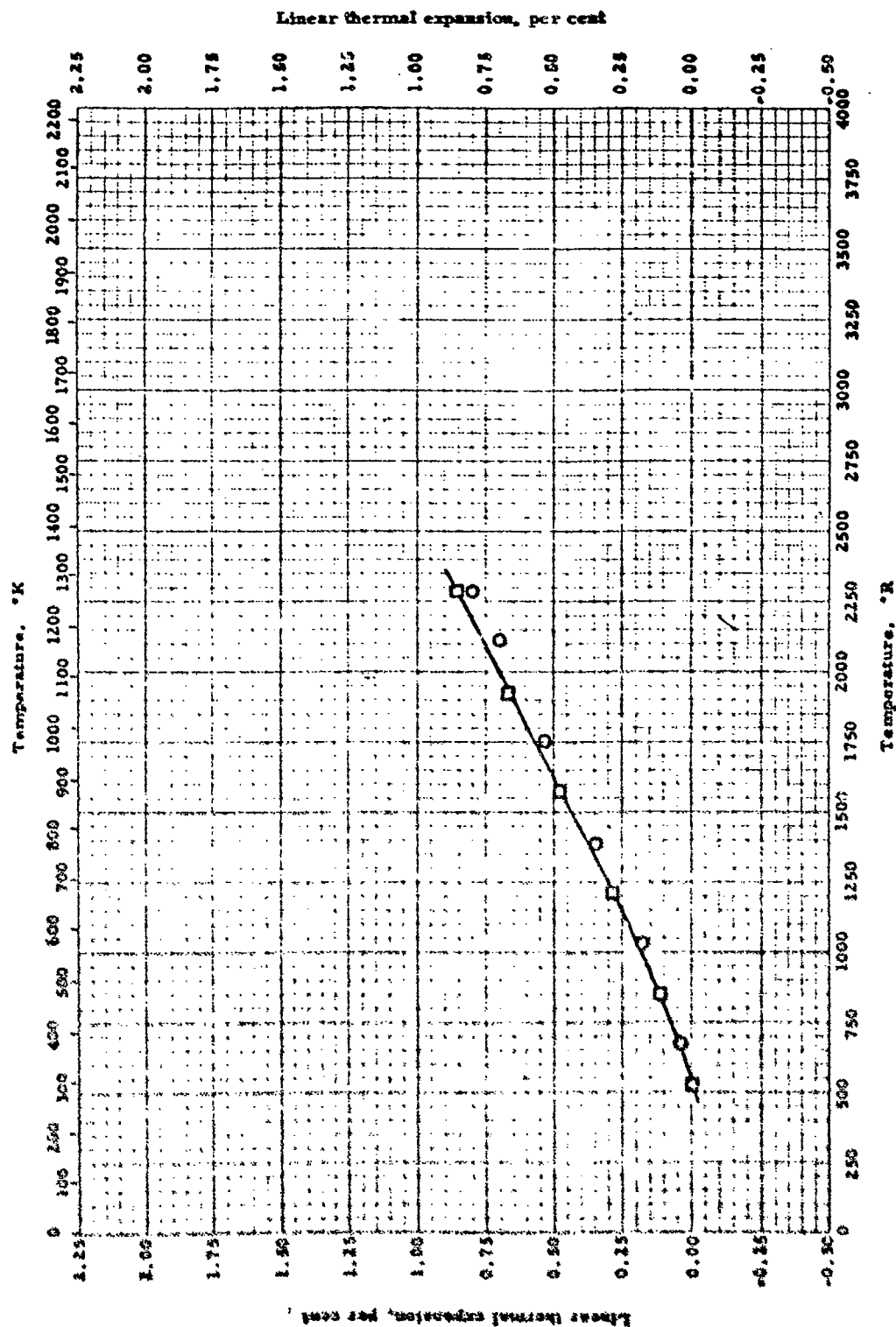
REFERENCE INFORMATION

Spec. No.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Perm. Scale	48-57	228-2292	BaO · Al ₂ O ₃	Not given	Fired 1 hr. at 1700 C

AO-626

WADC TR 35-476

632



LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINATE
(BeO · Al₂O₃) - CHRYSOBERYL

59-480

WADC TR 59-476

633

44-8-7-11A

LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINATE
(BeO · Al₂O₃) - CHRYSOBERYL

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Bestle, R., McKinnis, H. et al.	48-4	528-2292	Not given; nominal; 80.3% Al ₂ O ₃ ; 19.7% BeO	Not given	Fired 1 hr. at 1500°C
□	Geller, K. F., Yavoritsky, P. J. et al.	48-4	528-2292	Prepared from 99.7% pure BeO; 99+% pure Al ₂ O ₃	Interferometer	

PROPERTIES OF CALCIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	180 lb _m /ft ³	2.9 g/cm ³
Melting Point	3633°R	2018°K
Heat of Fusion		
Heat of Vaporisation		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft³ g/cm³
 □ 181 2.90

Melting Point: °R °K
 ○ 3633 ± 27 2018 ± 15
 □ 3633 ± 27 2018 ± 15

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporisation: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF CALCIUM ALUMINATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Boyko, E. R. and Wisnyi, L. G.	57-196	3600-3660	$\text{CaO} \cdot 2\text{Al}_2\text{O}_3$	MP: thermal arrest during slow cooling to obtain single crystals, temp. by W-Mo thermocouple	
□	Bruch, C. A. and Cashin, W. M.	56-109	3600-3660 Room	$\text{CaO} \cdot 2\text{Al}_2\text{O}_3$	MP: observation of first liquid drop on V-shaped ribbon, temp. by calibrated optical pyrometer p: not given	

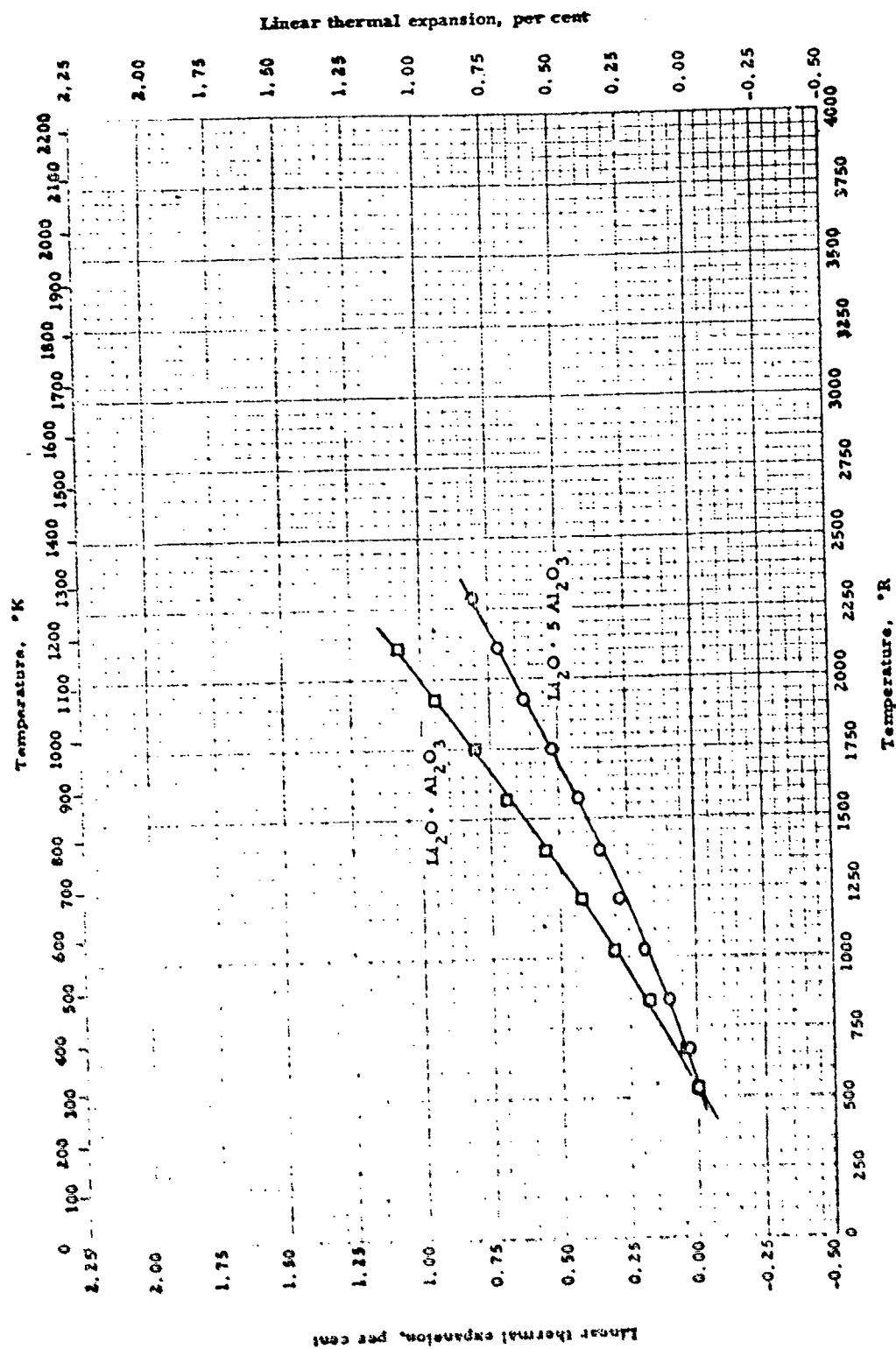


VII - B - 7 -

SPECIFIC HEAT -- CALCIUM ALUMINATE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-44	Kling, E. G.	55-44	96-537	CaO · 2Al ₂ O ₃ ; 76.49% Al ₂ O ₃ ; 21.58% CaO (cf. theor. 78.43% and 21.57%)	Guarded sample	
55-44	1314.	55-44	96-537	CaO · Al ₂ O ₃ ; 64.44% Al ₂ O ₃ ; 35.49% CaO (cf. theor. 64.51% and 35.49%)	Same as above	
55-44	1314.	55-44	96-537	12 CaO · 7Al ₂ O ₃ ; 51.2% Al ₂ O ₃ ; 48.32% CaO (cf. theor. 51.47% and 48.53%); 0.25% MgO + alkali oxides; 0.10% Fe ₂ O ₃	Same as above	
55-44	1314.	55-44	96-537	3CaO · Al ₂ O ₃ ; 62.25% CaO; 37.84% Al ₂ O ₃ (cf. theor. 62.26% and 37.74%)	Same as above	



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINATE

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Hummel, F. A.	51-21	528-2292	94.5% Al_2O_3 ; 5.5% Li_2O ($Li_2O \cdot 5Al_2O_3$); from c.p. Li_2CO_3 ; c.p. Al_2O_3 ; potter's flint	Dilatometer	Pressed 100 mesh calcined material at 1000 psi using Carbowax Methocel binder
□	Ibid.	51-21	528-2112	77.3% Al_2O_3 ; 22.7% Li_2O ($Li_2O \cdot Al_2O_3$); from c.p. Li_2CO_3 ; c.p. Al_2O_3 ; potter's flint	Same as above	Same as above

PROPERTIES OF STRONTIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	3690°R	2050°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K

○ 3678 ± 27 2043 ± 15

□ 3690 ± 36 2053 ± 20

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF STRONTIUM ALUMINATE

REFERENCE INFORMATION

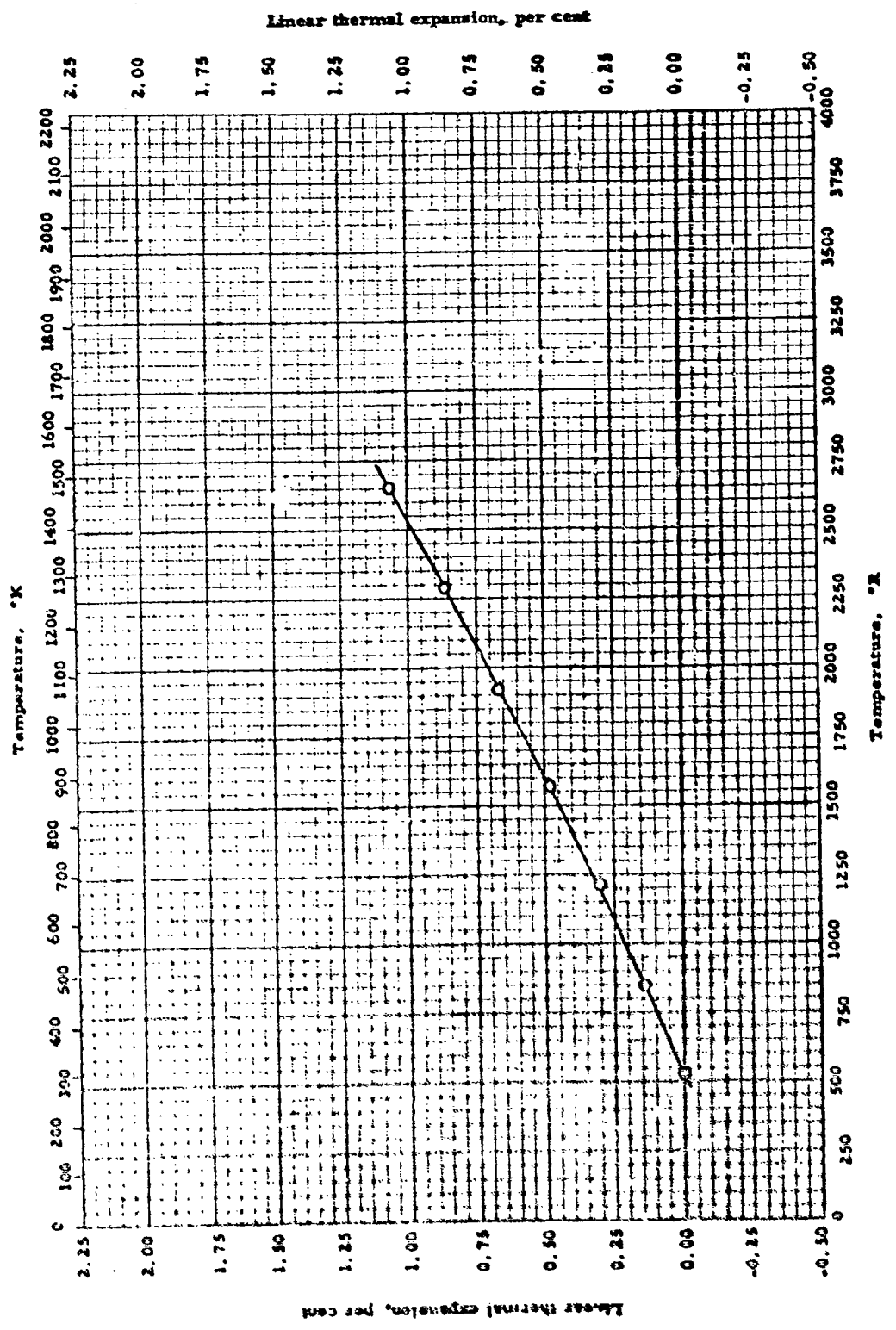
Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
57-196	Boyko, E. R. and Wisnyski, L. G.	3650-3715	$\text{SrO} \cdot 2\text{Al}_2\text{O}_3$	MP: thermal arrest during slow cooling to obtain single crystal. Temp. by W-Mo thermo- couple	
56-109	Bruch, C. A. and Cashin, W. M.	3660-3730	$\text{SrO} \cdot 2\text{Al}_2\text{O}_3$	MP: visual observation of sample in V-shaped ribbon; temp. by cali- brated optical pyro- meter	

59-275

WADC TR 58-476

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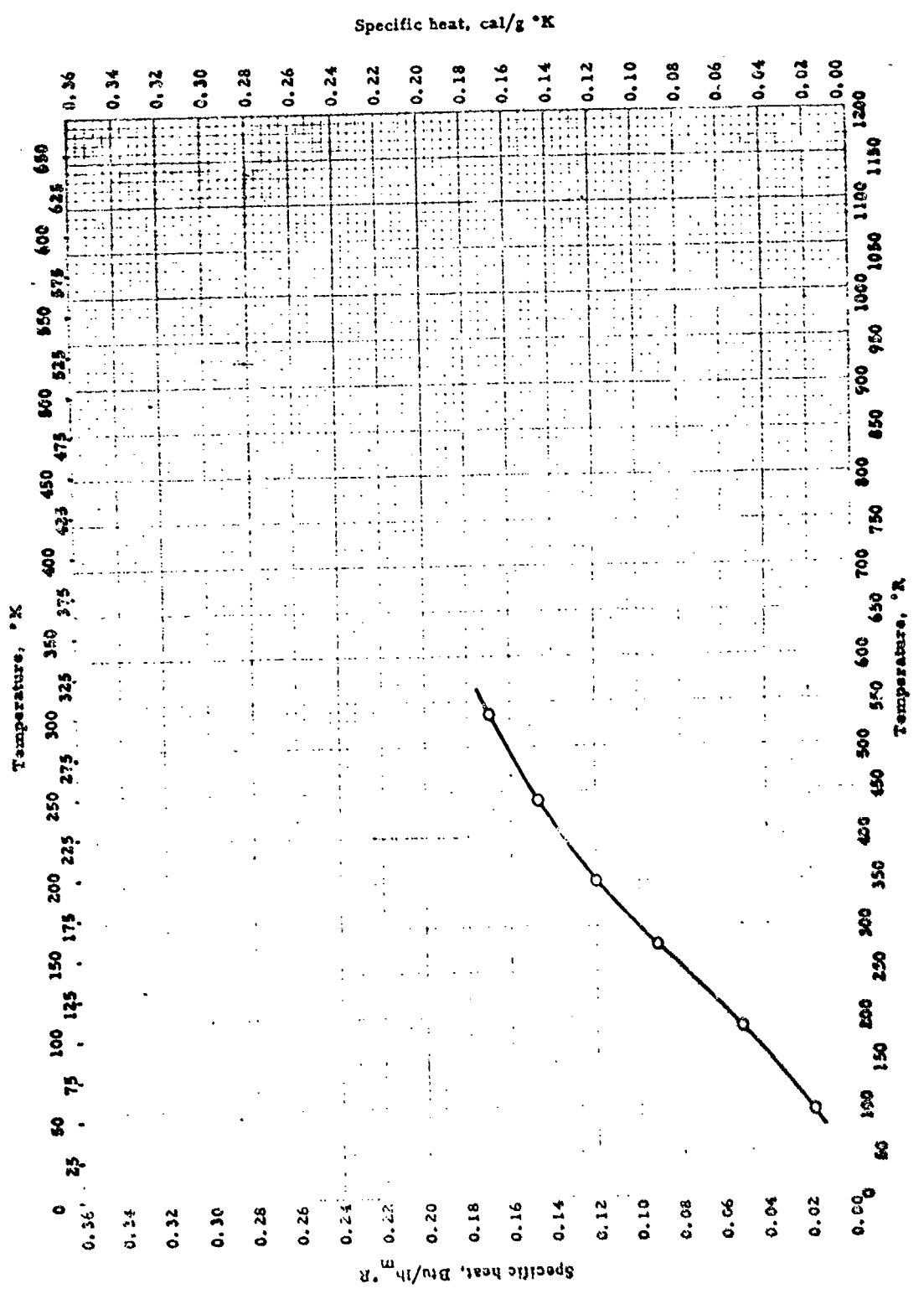
LINEAR THERMAL EXPANSION -- ZINC ALUMINATE

LINEAR THERMAL EXPANSION -- ZINC ALUMINATE

REFERENCE INFORMATION

Order No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Beale, R. J. and Goss, R. L.	57-20	528-2452	Prepared from reagent grade materials	X-ray back reflection	

60-709
WADC TR 58-476 645



SPECIFIC HEAT -- IRON ALUMINATE

SPECIFIC HEAT -- IRON ALUMINATE

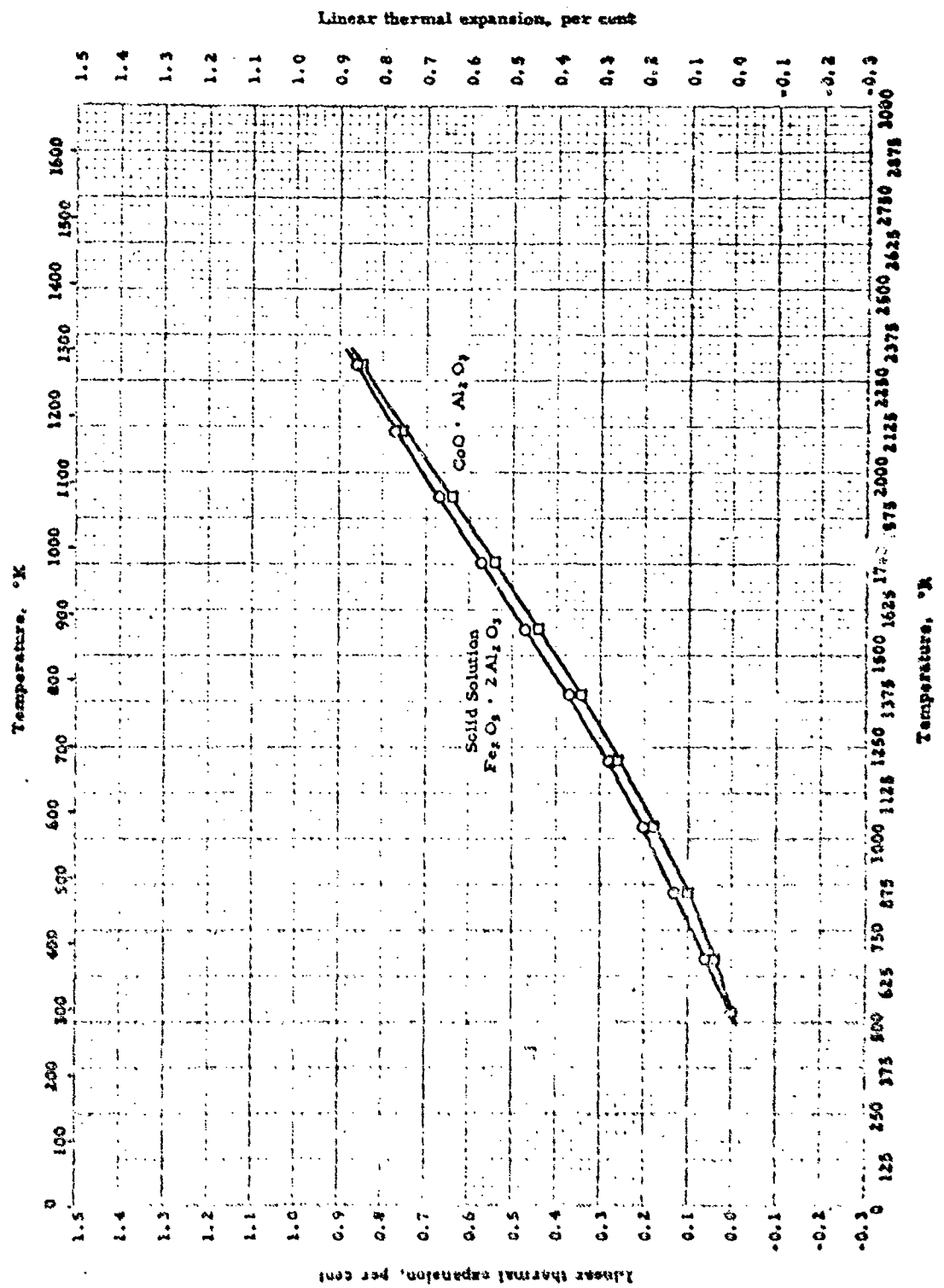
REFERENCE INFORMATION

Sym- bol	Investigator	E.L.	Range, °R	Material Composition	Test Method	Remarks
O	Klug, E. G.	56-165	95-540	FeAl ₂ O ₄ spinel: 58.62% Al ₂ O ₃ ; 41.24% FeO; 0.12% SiO ₂ . Theoretical 58.66% Al ₂ O ₃ ; 41.34% FeO	Not given	No evidence of uncombined oxides; metallic Fe on mag- netic particles found by x-ray diffraction; 7 heats totaling 40 hr, at 1250- 1350°C with grinding, mix- ing, etc. in between

60-709

WADC TR 58-476

646



LINEAR THERMAL EXPANSION -- ALUMINATES OF IRON AND COBALT

LINEAR THERMAL EXPANSION -- ALUMINATES OF IRON AND COBALT

REFERENCE INFORMATION

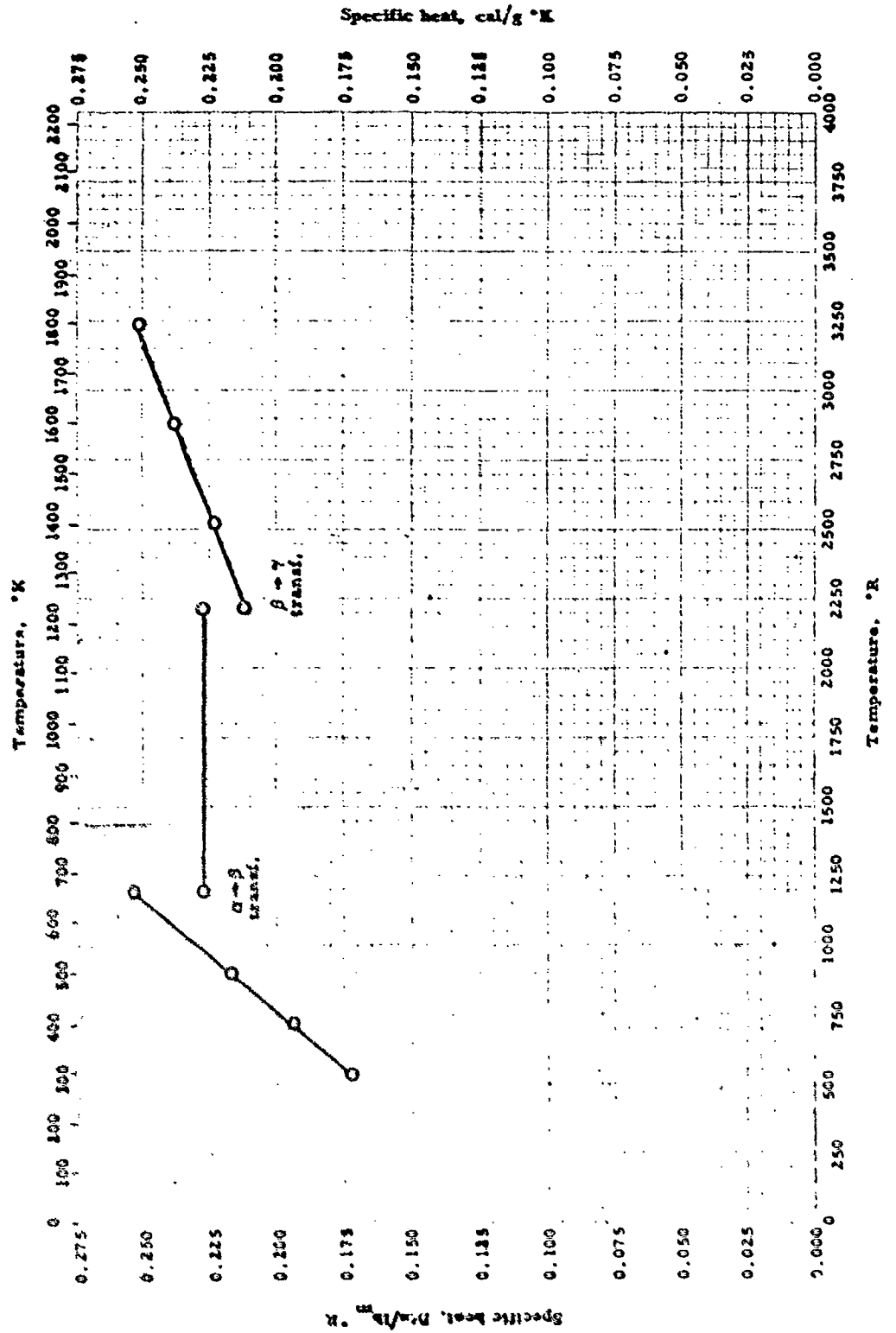
Ref.	Investigator	Ref.	Expts., °R	Material Composition	Test Method	Remarks
46-3	Slaby, G. R., Lovell, G. H. B., and Green, A. T.	46-3	672-2592	Solid solution $Fe_3O_4 \cdot 2Al_2O_3$ $p = 272 \text{ lb./sq. in.}$	Not given	
48-37	Penn. State College	48-37	528-2294	$CoO \cdot Al_2O_3$	Not given	Fired 1 hr. at 1700°C

59-491

WADC TR 58-476

649

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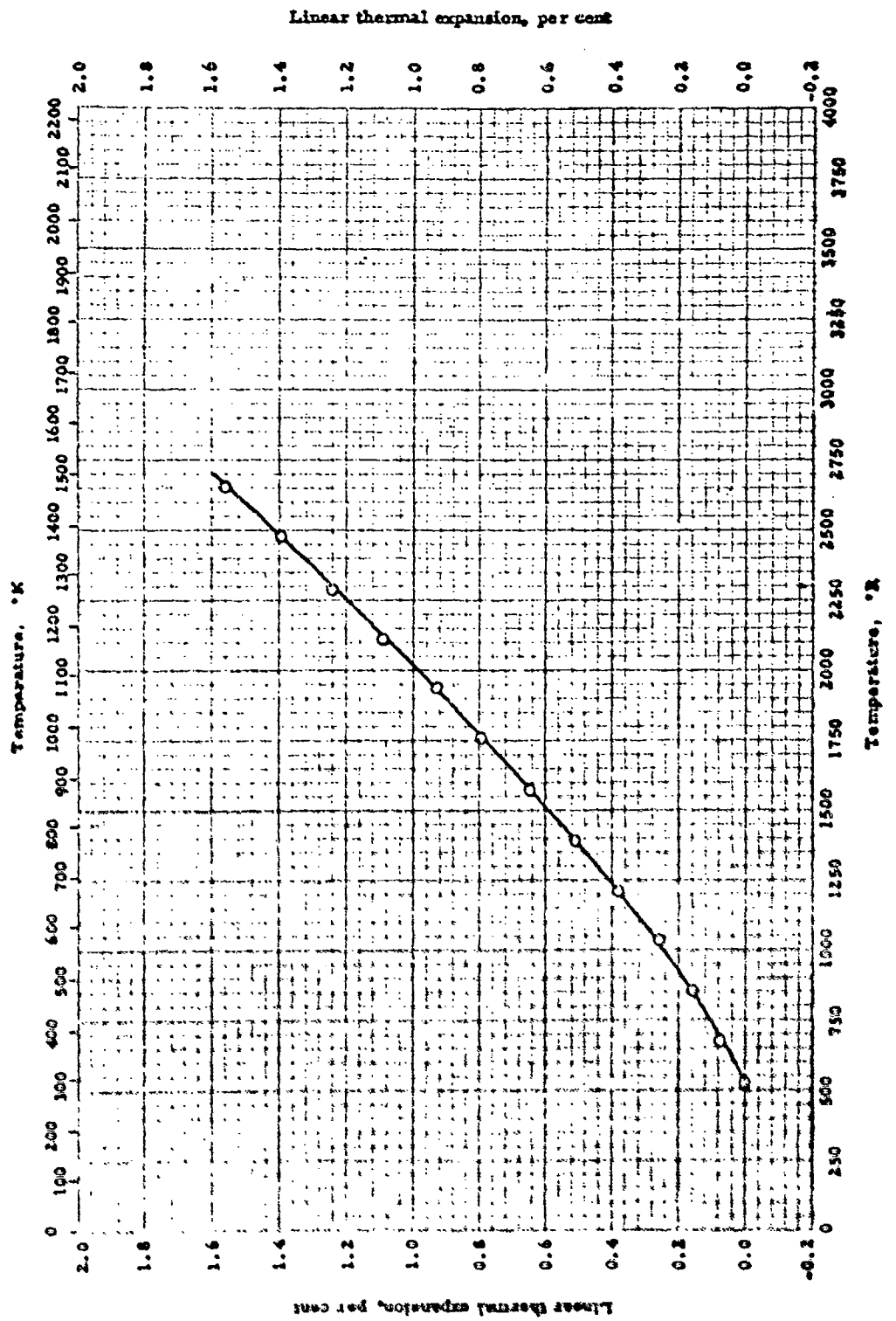


SPECIFIC HEAT -- MAGNESIUM FERRITE

SPECIFIC HEAT -- MAGNESIUM FERRITE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
54-42	Bonnicksom, K. R.	54-42	535-3310	MgFe ₂ O ₄ ; 79.74% Fe ₂ O ₃ ; 20.22% MgO (cf. theor. 79.84% and 20.16%); 0.14% SiO ₂	Drop method; metal block calorimeter	Prepared from reagent grade Fe ₂ O ₃ and MgO; heated repeatedly 900-1300°C; material analyzed and composition adjusted between heats



LINEAR THERMAL EXPANSION -- MAGNESIUM FERRITE

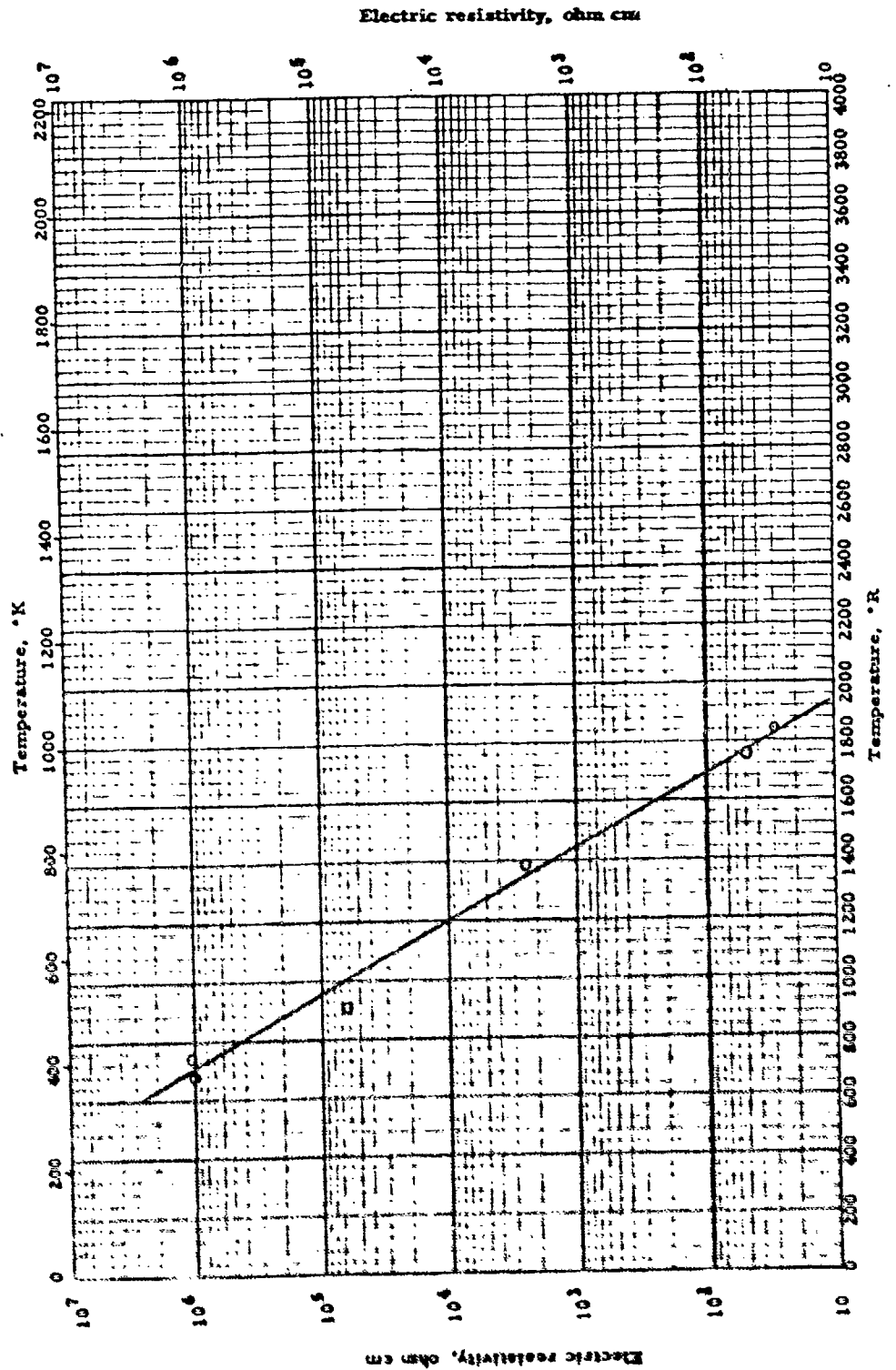
60-690
WADC TR 58-476 651

11A - 8 - 8 - 1

LINEAR THERMAL EXPANSION -- MAGNESIUM FERRITE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Rigby, G. R., Lovell, G. H. D. and Green, A. T.	46-8	672-2652	MgFe ₂ O ₄ . ρ = 262 lb _m /ft ³	Not given	MgO and Fe ₂ O ₃ mixed, heated 2 hr. at 1200 C in air, crushed, reheated



59-1089

WADC TR 58-476

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ELECTRIC RESISTIVITY -- MAGNESIUM FERRITE

ELECTRIC RESISTIVITY -- MAGNESIUM FERRITE

REFERENCE INFORMATION

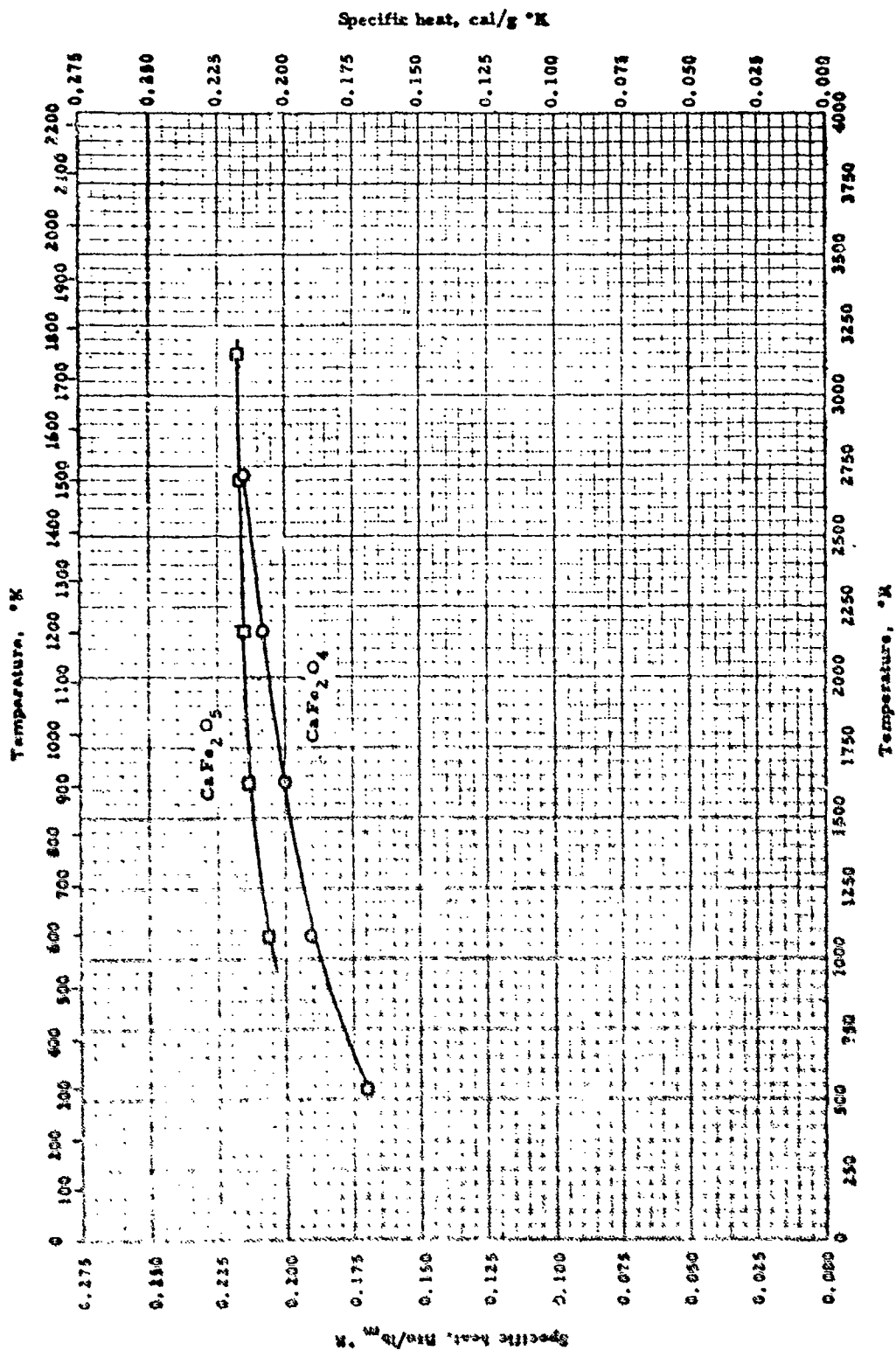
Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirvel, L.	51-49	672-1836	MgO · Fe ₂ O ₃	Potential drop	

59-761

WADC TR 58-476

655

VII - B - 4

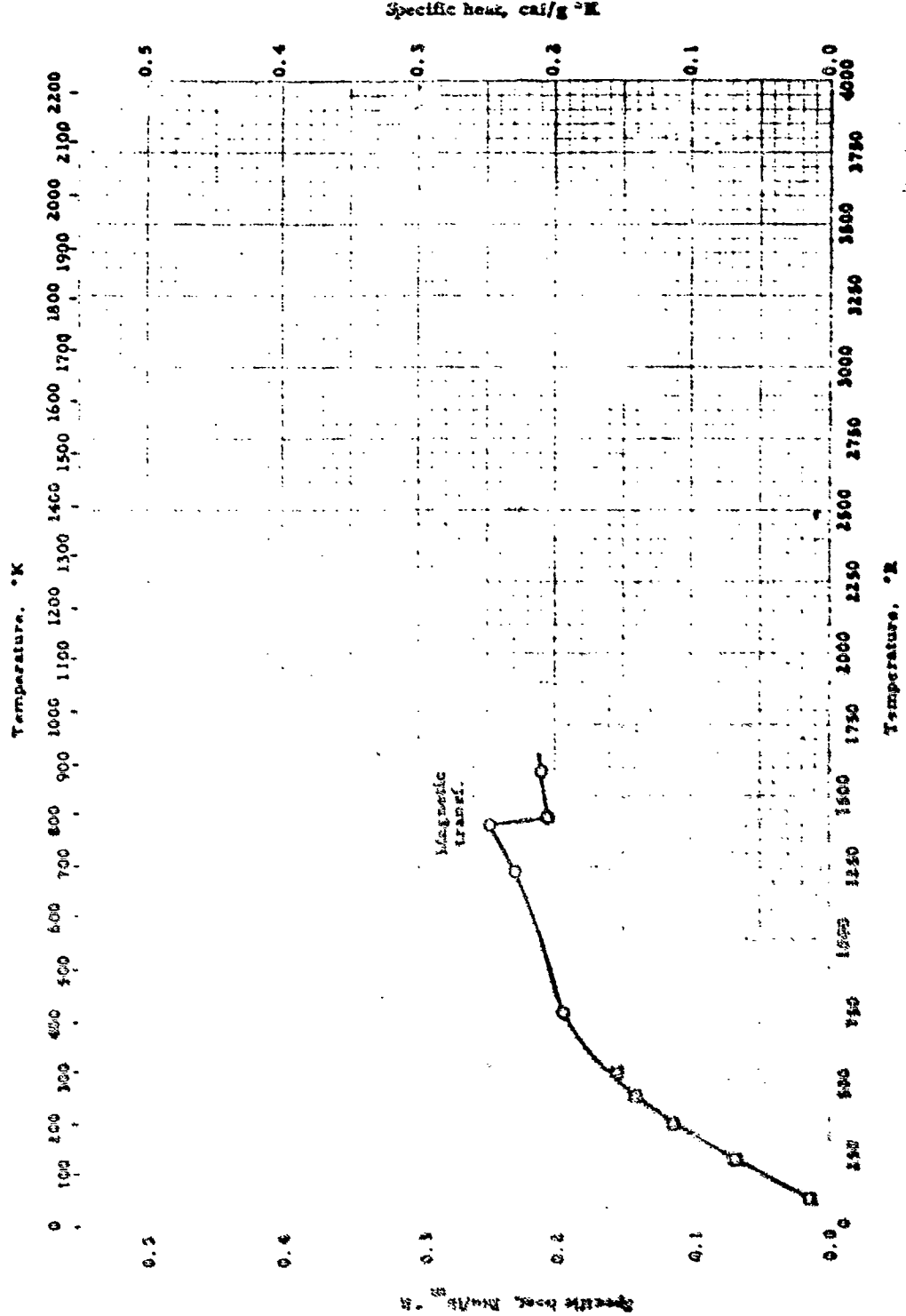


SPECIFIC HEAT -- CALCIUM FERRITE

SPECIFIC HEAT -- CALCIUM FERRITE

REFERENCE INFORMATION

Spec bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
<input checked="" type="radio"/>	Donnan-Chapman, H. R.	54-62	535-1335	Ca Fe ₂ O ₄ : 74.05% Fe ₂ O ₃ (74.0% theoretical) 25.95% CaO (25.99% theoretical) prepared from reagent grade Fe ₂ O ₃ and CaCO ₃	Drop method; copper block calorimeter	Ground mixed; heated to 1000 - 1200 °C for several hours; repeated several times adjusting composition between heating cycles
<input type="radio"/>	Ibid.	54-62	535-1310	Ca ₂ Fe ₂ O ₅ : 58.71% Fe ₂ O ₃ ; 41.27% CaO; raw material same as above	Same as above	Same as above except heat- ed to 850 to 1230 °C



SPECIFIC HEAT -- COBALT FERRITE

59-1029

WASH. TN 58-476

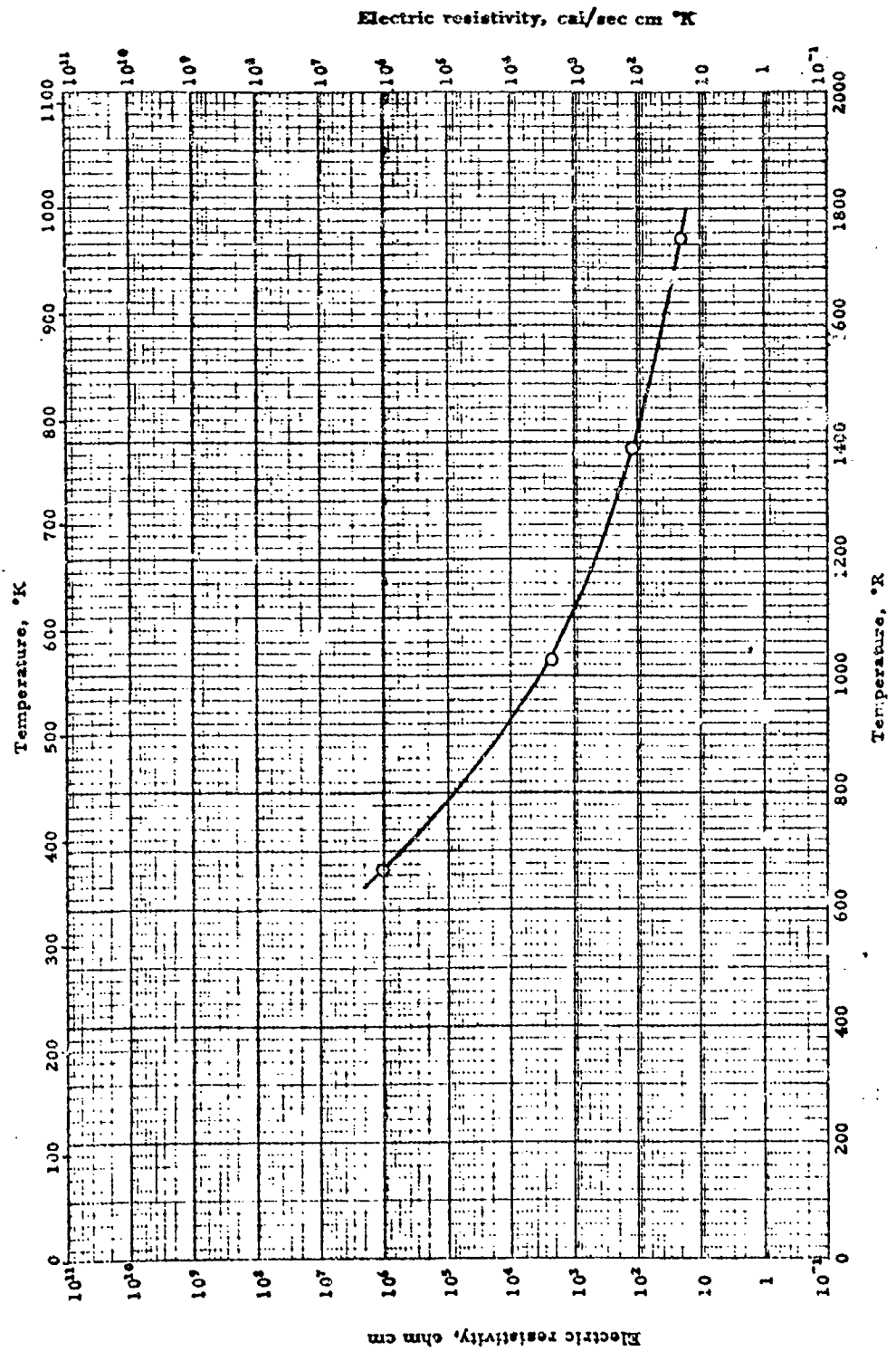
657

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SPECIFIC HEAT -- COBALT FERRITE

REFERENCE INFORMATION

SYM No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Wachiral, L.	51-54	744-1550	$Y_2O_3 \cdot CoO$	Not given here, refers to others	X-ray diffraction agreed with ASTM; no evidence of uncombined oxides. Ground, mixed, analysed, composition adjusted, heated 5 times for total of 9 days in temp. range 750-1350°C
Q	King, E. G.	56-145	95-537	CoY_2O_4 spinel, 68.03% Y_2O_3 (48.06% theo.); 31.96% CoO (31.96% theo.); 0.07% SiO_2	Guarded sample	



60-630
WADC TR 58-476 659

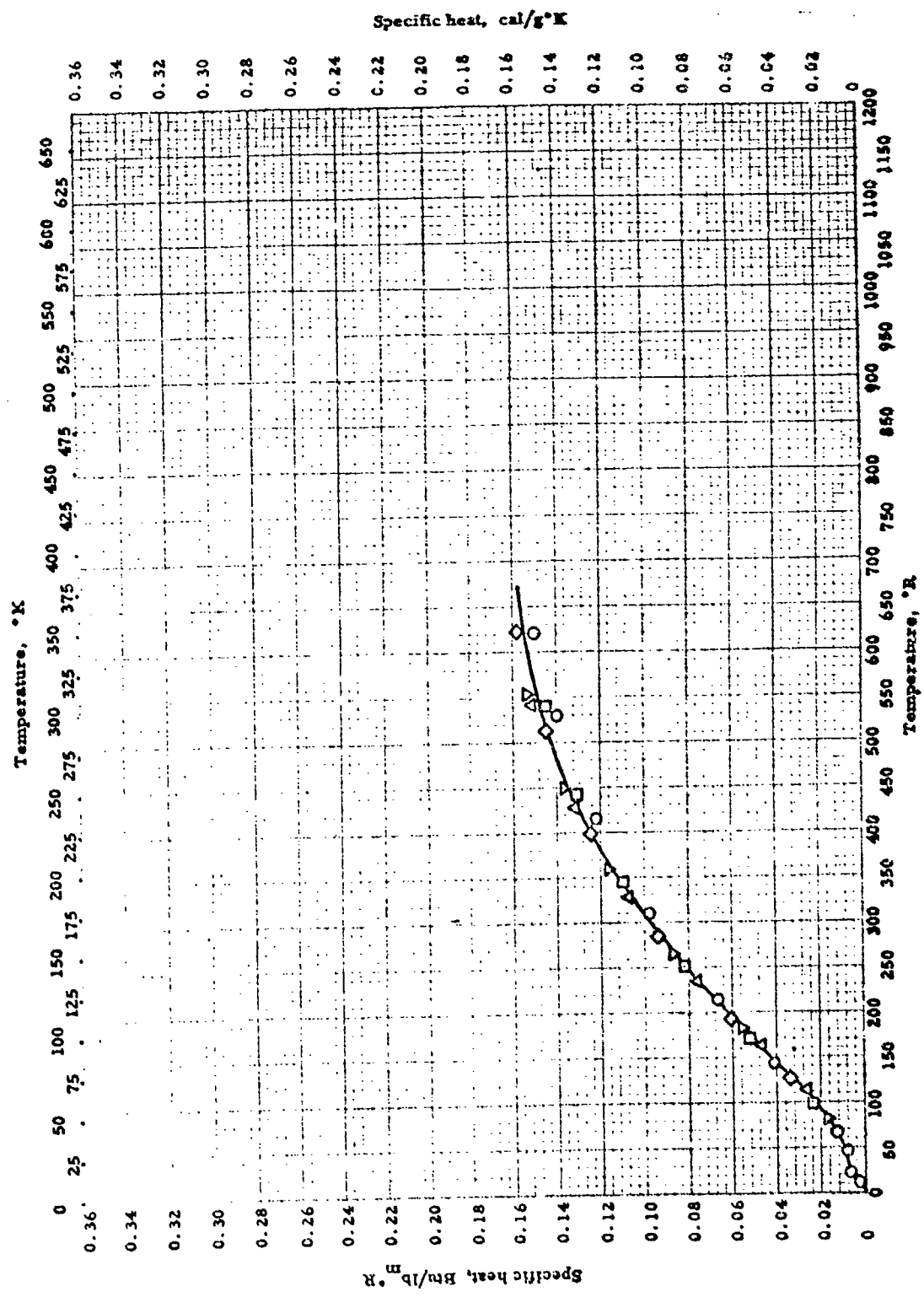
VII - B - 8 -

ELECTRIC RESISTIVITY -- COBALT FERRITE

ELECTRIC RESISTIVITY -- COBALT FERRITE

REFERENCE INFORMATION

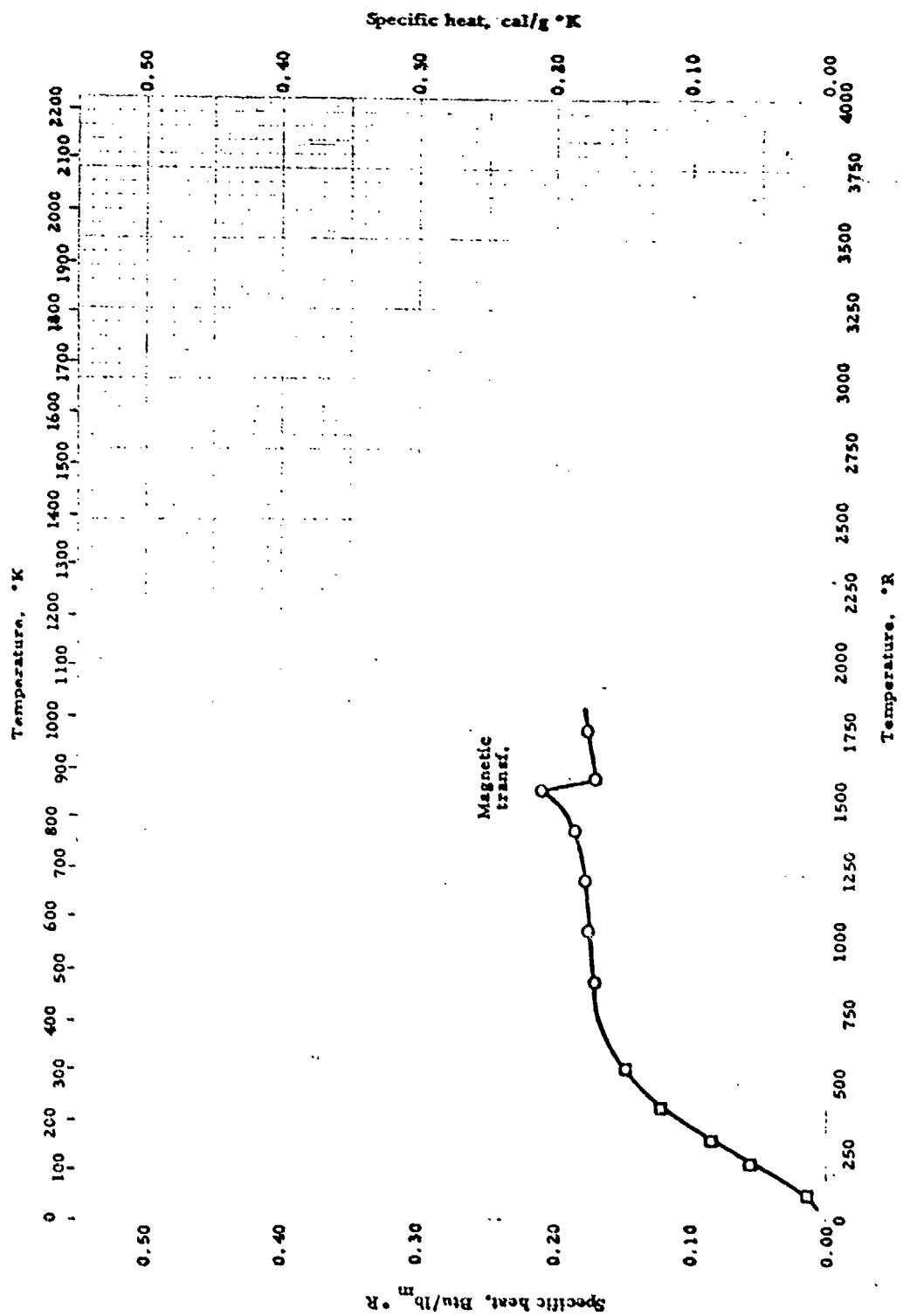
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1752	Fe ₂ O ₃ CoO	Potential drop, using potentiometer	Sintered discs



60-533
 WADC TR 58-476 661

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Grimes, D. M., Westrum, E. F. and Legvold, S.	57-195	10-622	$\text{Ni}_{0.1}\text{Zn}_{0.9}\text{Fe}_2\text{O}_4$	Guarded sample, temp. by platinum resistance thermom- eter	Annealed at 1200°C, very pure sample, carefully prepared
□	Ibid.	57-195	8-536	$\text{Ni}_{0.2}\text{Zn}_{0.3}\text{Fe}_2\text{O}_4$; 46.7 ± 0.1% Fe (theoretical 46.59%)	Same as above	Same as above
△	Ibid.	57-195	8-542	$\text{Ni}_{0.4}\text{Zn}_{0.6}\text{Fe}_2\text{O}_4$; 46.8 ± 0.1% Fe (theoretical 46.64%)	Same as above	Same as above, but annealed at 900° C
◇	Ibid.	57-195	10-623	$\text{Ni}_{0.3}\text{Zn}_{0.7}\text{Fe}_2\text{O}_4$	Same as above	Same as above, but annealed at 1200°C
▽	Ibid.	57-195	10-550	Ferramic E: $\text{Ni}_{0.4}\text{Zn}_{0.6}\text{Fe}_2\text{O}_4$ commercial grade material	Same as above	

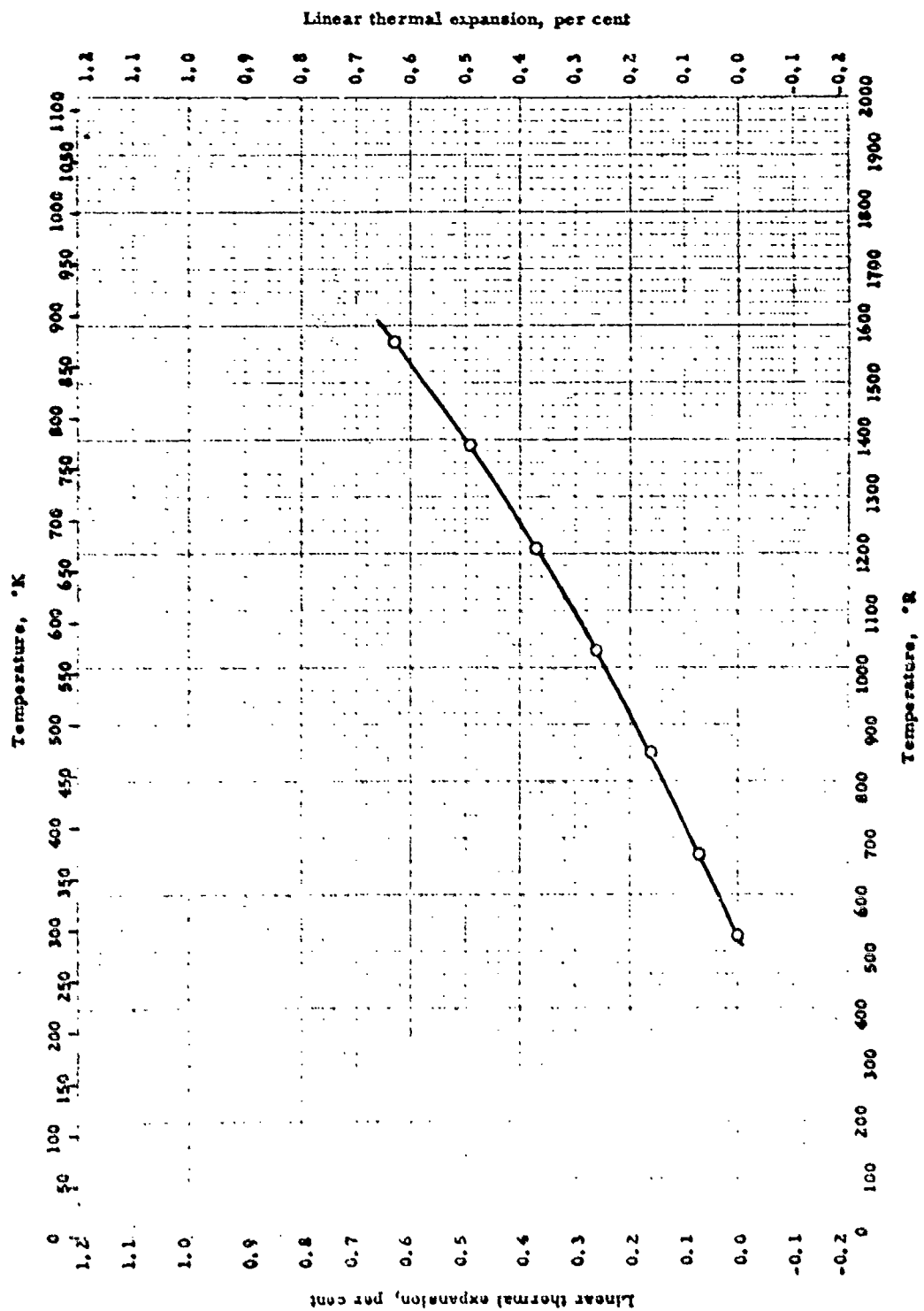


SPECIFIC HEAT -- NICKEL FERRITE

SPECIFIC HEAT -- NICKEL FERRITE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochiroh, L.	51-32	852-1752	NiO · Fe ₂ O ₃	Not given here; refers to others	X-ray diffraction agreed with ASTM; no impurity line detected. Heated to 990-1270°C for prolonged periods, with grinding, mixing, etc. in between heats
□	King, E. G.	56-165	96-537	NiFe ₂ O ₄ spinel: 68.11% Fe ₂ O ₃ (68.13% theo.); 31.66% NiO (31.87% theo.); 27.22% O ₂ (27.33% theo.); 0.03% SiO ₂	Guarded sample	



LINEAR THERMAL EXPANSION -- NICKEL FERRITE

LINEAR THERMAL EXPANSION -- NICKEL FERRITE

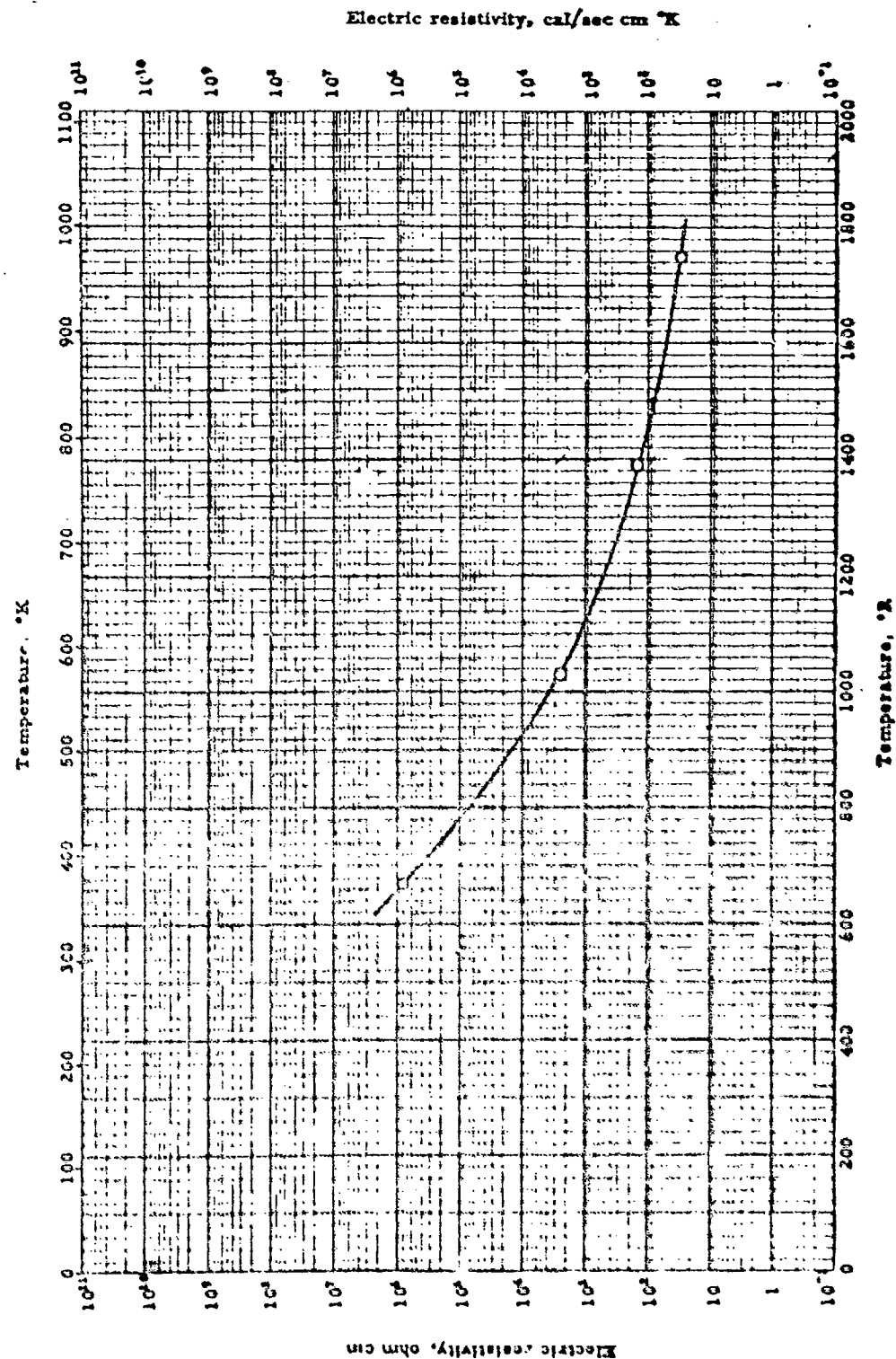
REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Augustinix, A. I. and Vasiliev, E. I.	56-162	672-1572	NiO · Fe ₂ O ₃ ; 68.13% Fe ₂ O ₃ ; 31.87% NiO	Dilatometer	

60-628

WADC TR 58-476

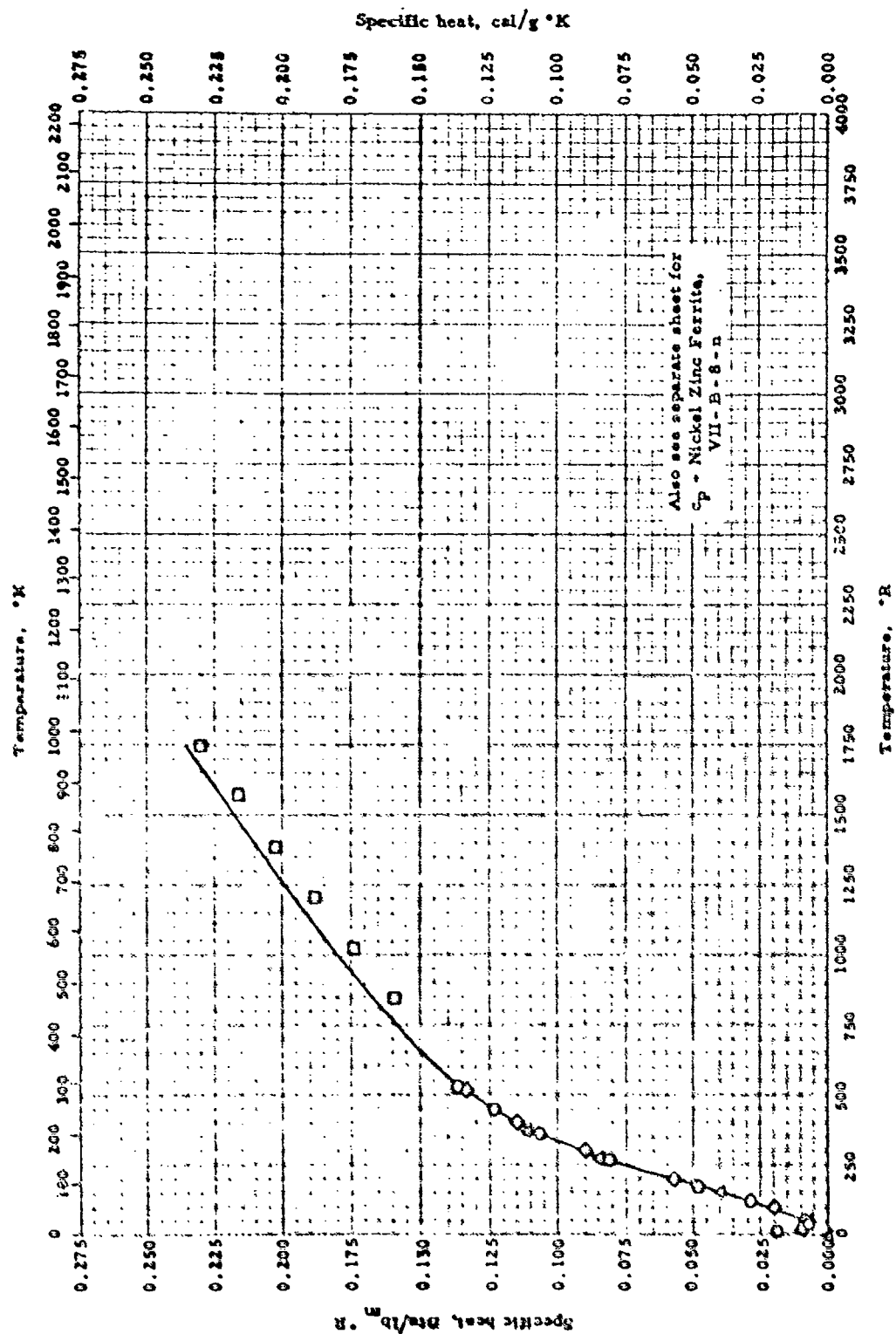
666



ELECTRIC RESISTIVITY -- NICKEL FERRITE

REFERENCE INFORMATION

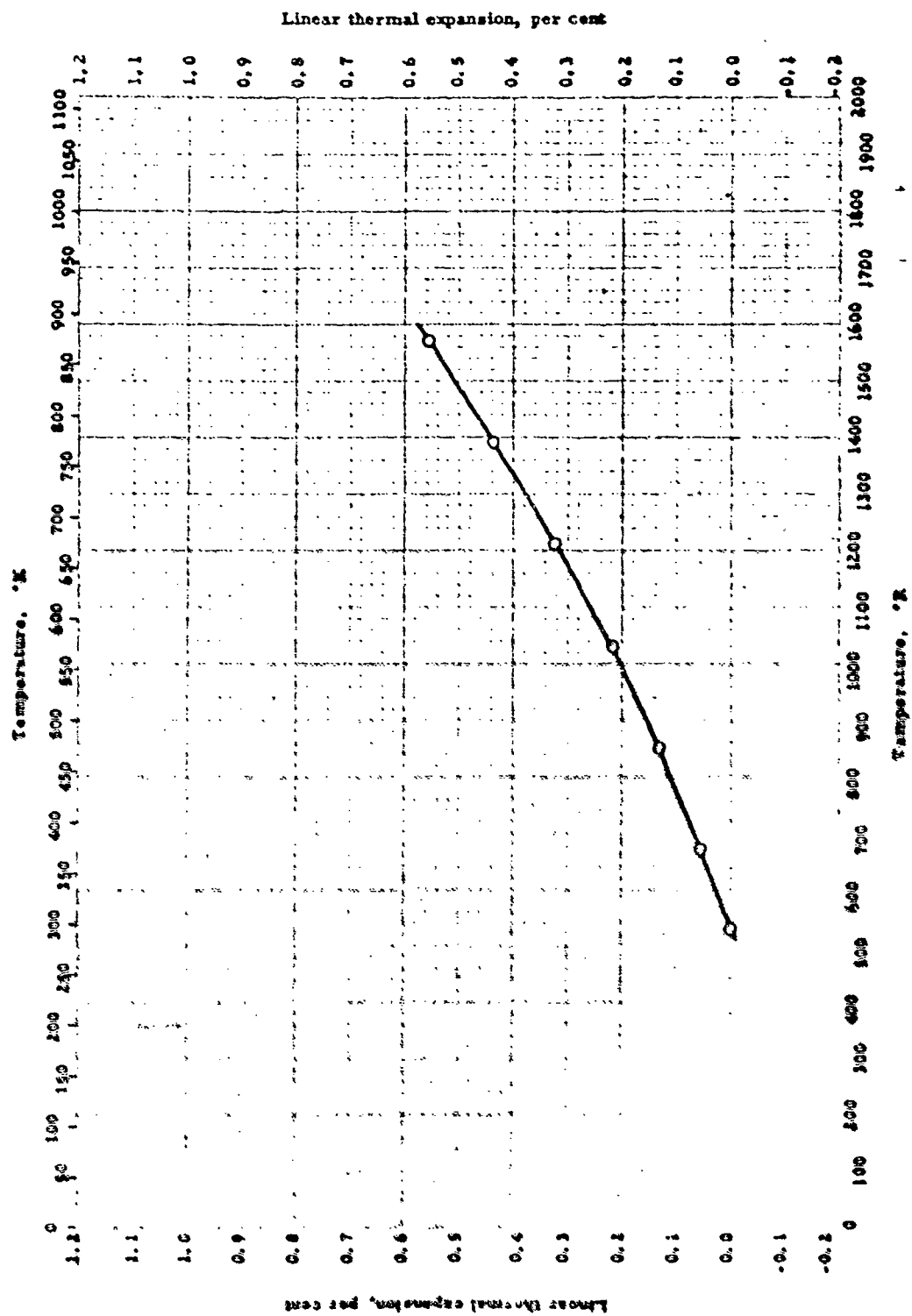
Sym	Investig tor	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bocklrol, L.	51-49	672-1752	Fe ₂ O ₃ · NiO	Potential drop, using potentiometer	Sintered discs



SPECIFIC HEAT -- ZINC FERRITE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
57-49 also 57-195	Westrum, Jr., E. F. and Grimes, D. M.	57-49 also 57-195	18-536	$ZnFe_2O_4$: 46.24 ± 0.1% Fe (cf. theor. 46.33); 27.2 ± 0.1% Zn (cf. theor. 27.12); <0.1% ferrous Fe; 0.01-0.1% ea. Al, Mn; 0.001-0.01% ea. Ca, Cu, Mg, Ni, S	Guarded sample	Pressed, fired 14 hr. at 1100°C in air, fragmented to pass 30-mesh screen, re- formed into slugs, fired 12 hr. at 1100°C, and furnace cooled in 16 hr.
31-12	Doehring, L.	31-12	832-1732	$Fe_2O_3 \cdot ZnO$	Not given. (lists ref.)	
46-12	Friedberg, S. A.	46-12	0-360	$ZnO \cdot Fe_2O_3$	Not described here, re- fers to others	
35-164	Xing, S. G.	35-164	93-540	$ZnFe_2O_4$. Spinel: 66.36% Fe_2O_3 ; 33.64% ZnO	Guarded sample	Heated to 940-1280°C sev- eral times (total 18 days) with grinding, mixing, etc. in between heatings

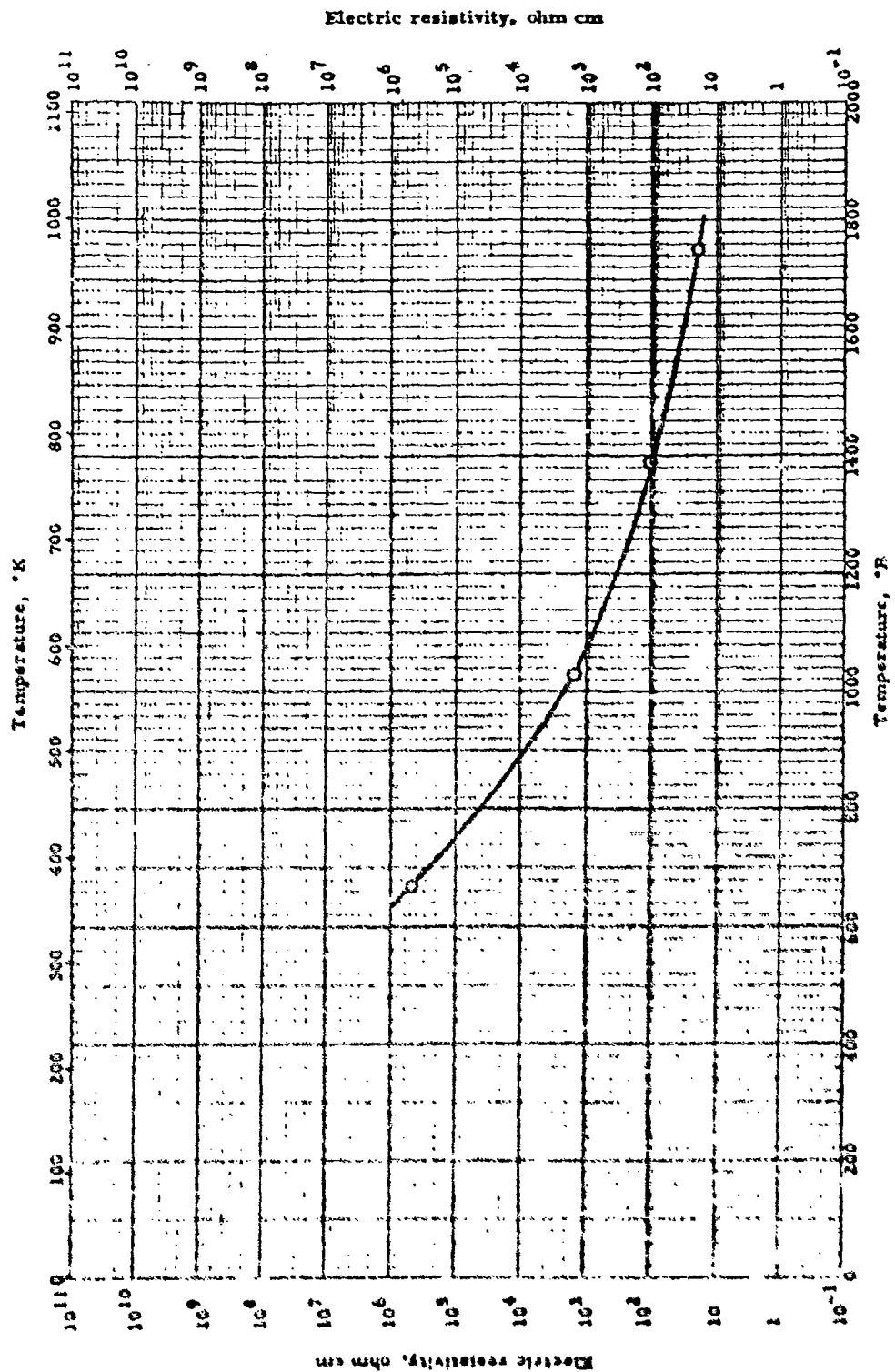


LINEAR THERMAL EXPANSION -- ZINC FERRITE

LINEAR THERMAL EXPANSION -- ZINC FERRITE

REFERENCE INFORMATION

Order No.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
0	Augustine, A. L. and Vasil'ev, E. L.	58-162	672-1572	ZnO · Fe ₂ O ₃ ; 66.2% Fe ₂ O ₃ ; 33.8% ZnO	Dilatometer	



ELECTRIC RESISTIVITY -- ZINC FERRITE

ELECTRIC RESISTIVITY -- ZINC FERRITE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochler, L.	51-49	672-1732	$\text{Fe}_2\text{O}_3 \cdot 2\text{ZnO}$	Potential drop, using potentiometer	Sintered discs

PROPERTIES OF MANGANESE FERRITE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	293 lb _m /ft ³	4.7 g/cm ³
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	291.4	4.67
□	300.8	4.82
△	290.8	4.66
◇	292.7	4.69

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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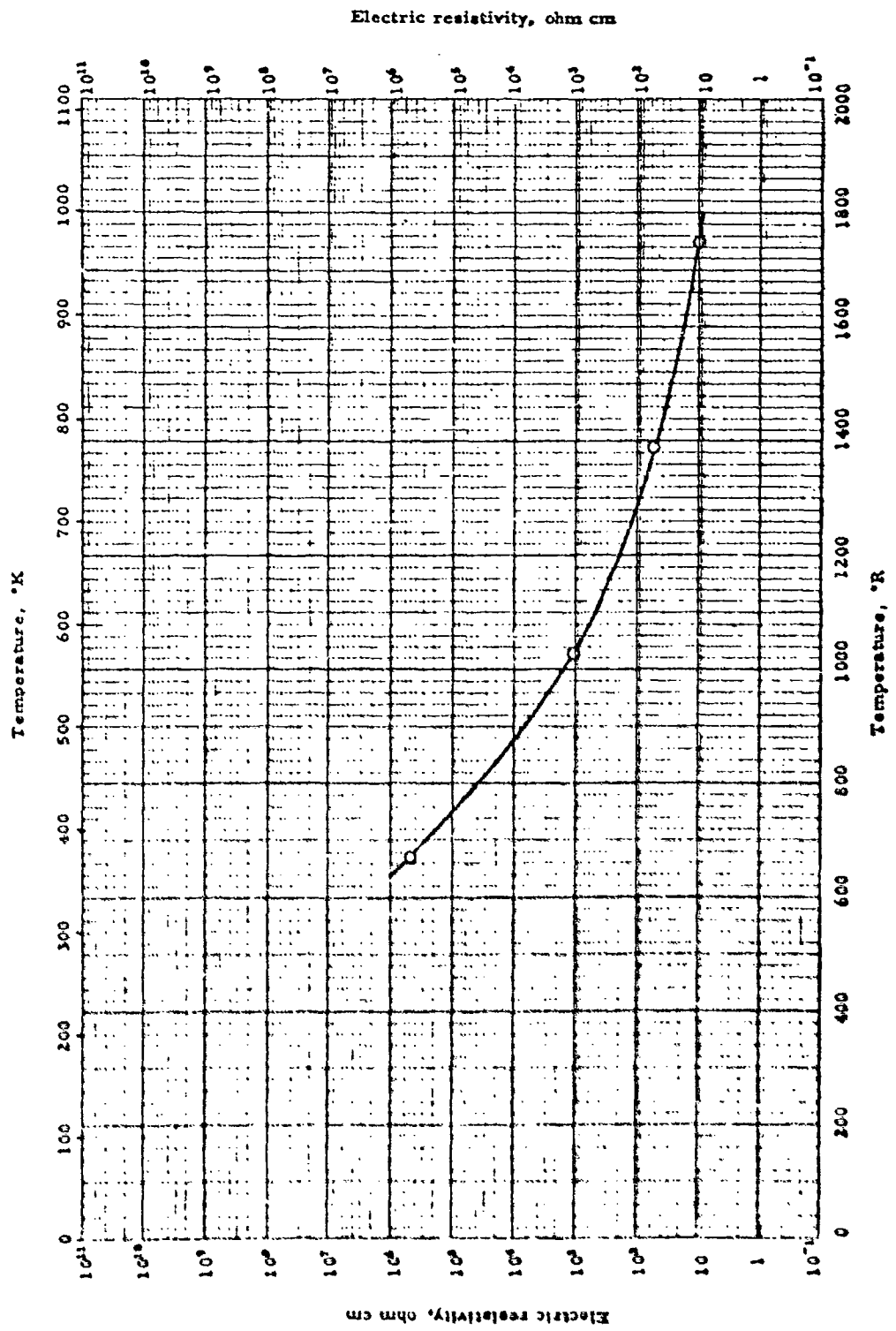
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF MANGANESE FERRITE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Economos, G.	55-145	Room	MnFe ₂ O ₄	p: displacement in acetone	MnCO ₃ and iron oxide heated 6 hrs. at 550°C; mixing and more heating gave final mixtures which were pressed and sintered. Fired in stagnant air
□	Ibid.	55-145	Room	Same as above	p: same as above	Same as above but fired in CO-CO ₂ (an equilibrium atmos.)
△	Ibid.	55-145	Room	Same as above	p: same as above	Same as above but fired in CO ₂
◇	Ibid.	55-145	Room	Same as above	p: same as above	Same as above but fired in He



ELECTRIC RESISTIVITY -- COPPER FERRITE

ELECTRIC RESISTIVITY -- COPPER FERRITE

REFERENCE INFORMATION

Spec Lot	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Bochirof, L.	51-49	672-1752	Fe ₂ O ₃ CuO	Potential drop, using potentiometer	Sintered discs

DENSITY -- MICA

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	177.6 lb _m /ft ³	2.845 g/cm ³
Melting Point.		
Heat of Fusion.		
Heat of Vaporization.		
Heat of Sublimation.		

REPORTED VALUES

Density: lb_m/ft³ g/cm³
O 177.6 ± 0.06 2.845 ± 0.001

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

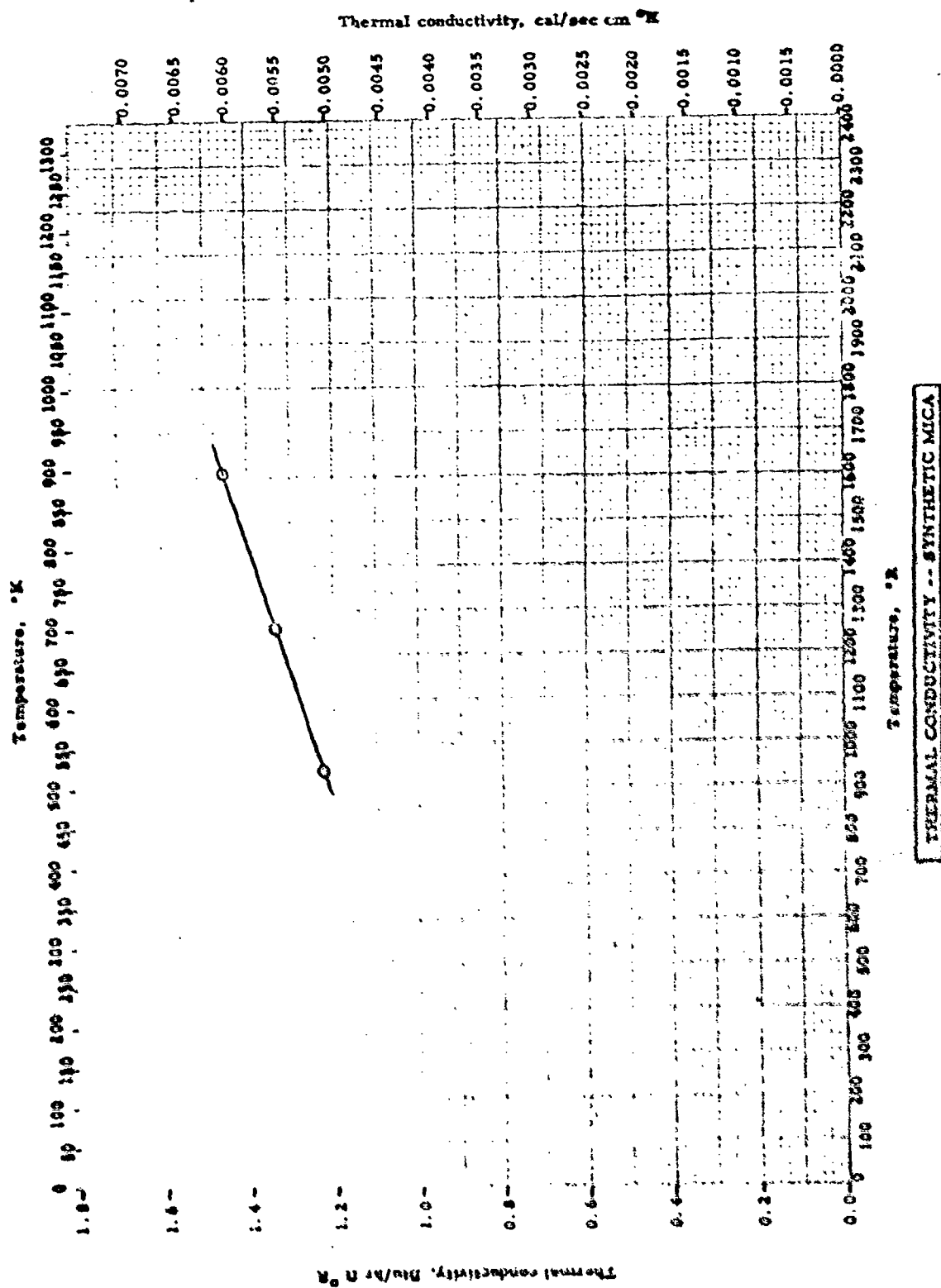
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

DENSITY -- MICA

REFERENCE INFORMATION

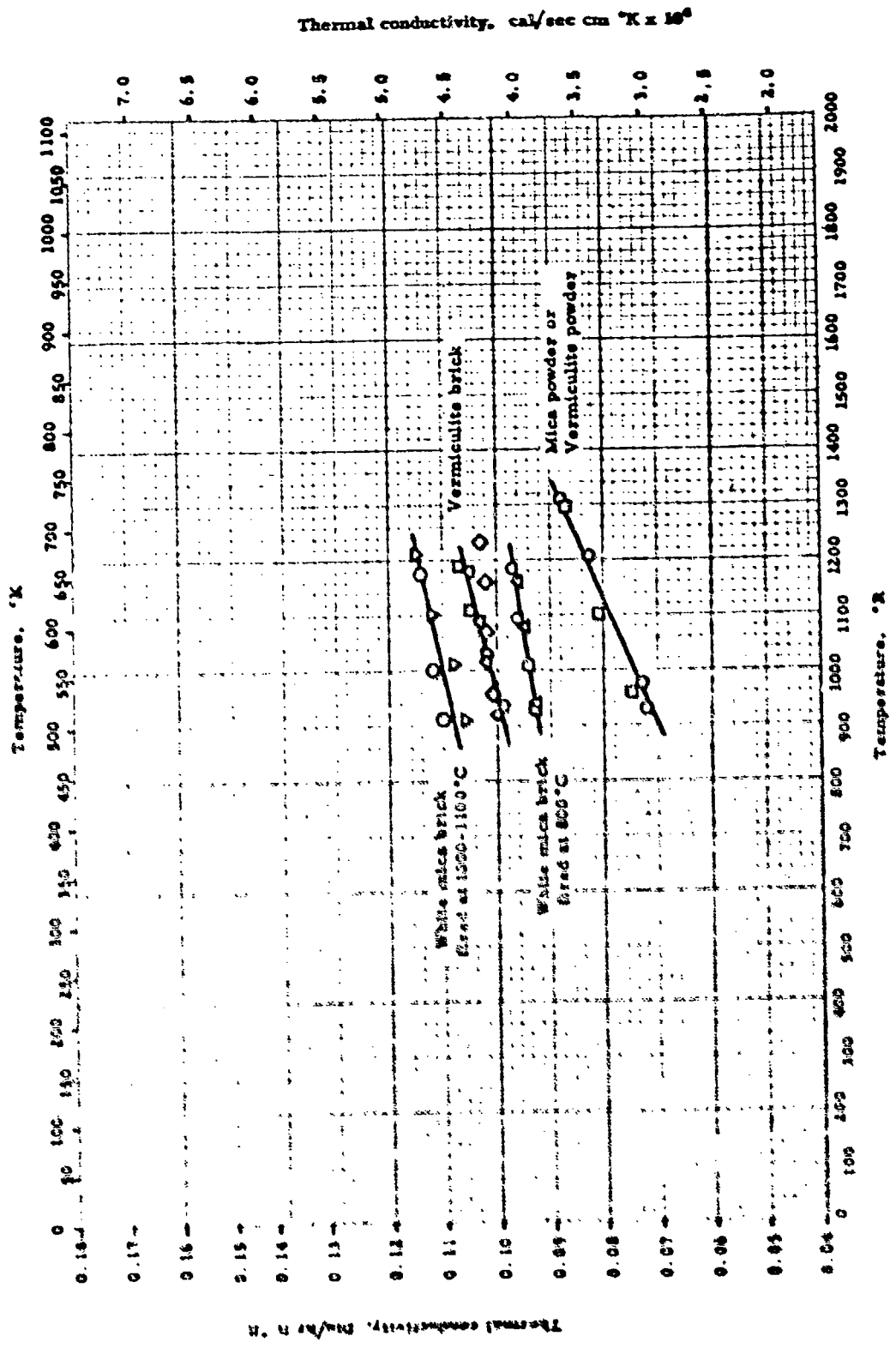
Sym No.	Investigator	Ref	Range, °R	Material Composition	Test Method	Remarks
O	Oak Ridge National Laboratory	57-450	537	Mica	p: weight in air and in kerosene	Measured by O. Sieman, C. D. Bopp and R. L. Toms



THERMAL CONDUCTIVITY -- SYNTHETIC MICA

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	McGough, L. R.	ST-144	942-1400	9 - 98% of char.		

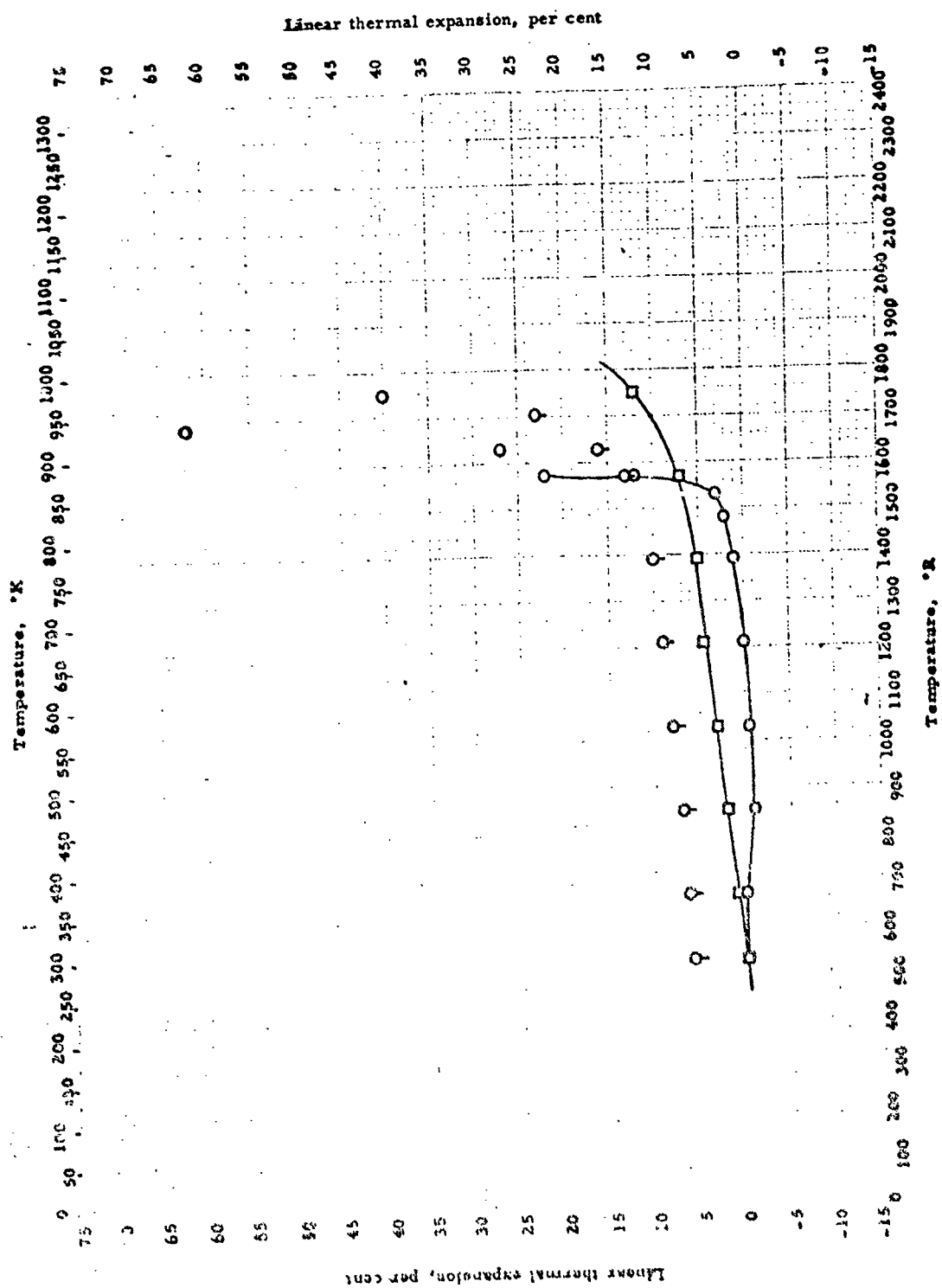


Thermal conductivity -- MICA
(Powder and Brick)

THERMAL CONDUCTIVITY -- MICA
(Powder and Brick)

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
57.	Proctor, B. M. and Frye, J. J.	912-1112	Mica insulating powders, $\rho = 20.7 \text{ lb}_m/\text{ft}^3$	Single flat plate; water calorimeter	
938-1297			Vermiculite insulating powders, $\rho = 16.7 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 850°C
942-1160			White mica brick, $\rho = 42.7 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 900°C
958-1232			Same as above, $\rho = 41.2 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 1000°C
915-1212			Same as above, $\rho = 41.5 \text{ lb}_m/\text{ft}^3$	Same as above	Fired at 1100°C
912-1179			Same as above, $\rho = 41.6 \text{ lb}_m/\text{ft}^3$	Same as above	
928-1146			White mica insulating brick, $\rho = 43.9 \text{ lb}_m/\text{ft}^3$	Same as above	
922-1161			Red mica insulating brick, $\rho = 44.0 \text{ lb}_m/\text{ft}^3$	Same as above	
927-1187			Vermiculite insulating brick, $\rho = 30.2 \text{ lb}_m/\text{ft}^3$	Same as above	



LINEAR THERMAL EXPANSION -- IKON MICA (BIOTITE)

LINEAR THERMAL EXPANSION -- IRON MICA (BIOTITE) *

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hildner, P., and Dixon, G.	45-2	528-1752	From Oxford County, Maine	Fused quartz dilatometer	Measured perpendicular to cleavage plane; 1st heating and cooling cycle. Q - heating; Q - cooling
C	Ibid.	45-2	528-1752	From Newdale, N. C.	Same as above	Measured perpendicular to cleavage plane; 6th heating cycle. The above data are representative; for additional information see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples

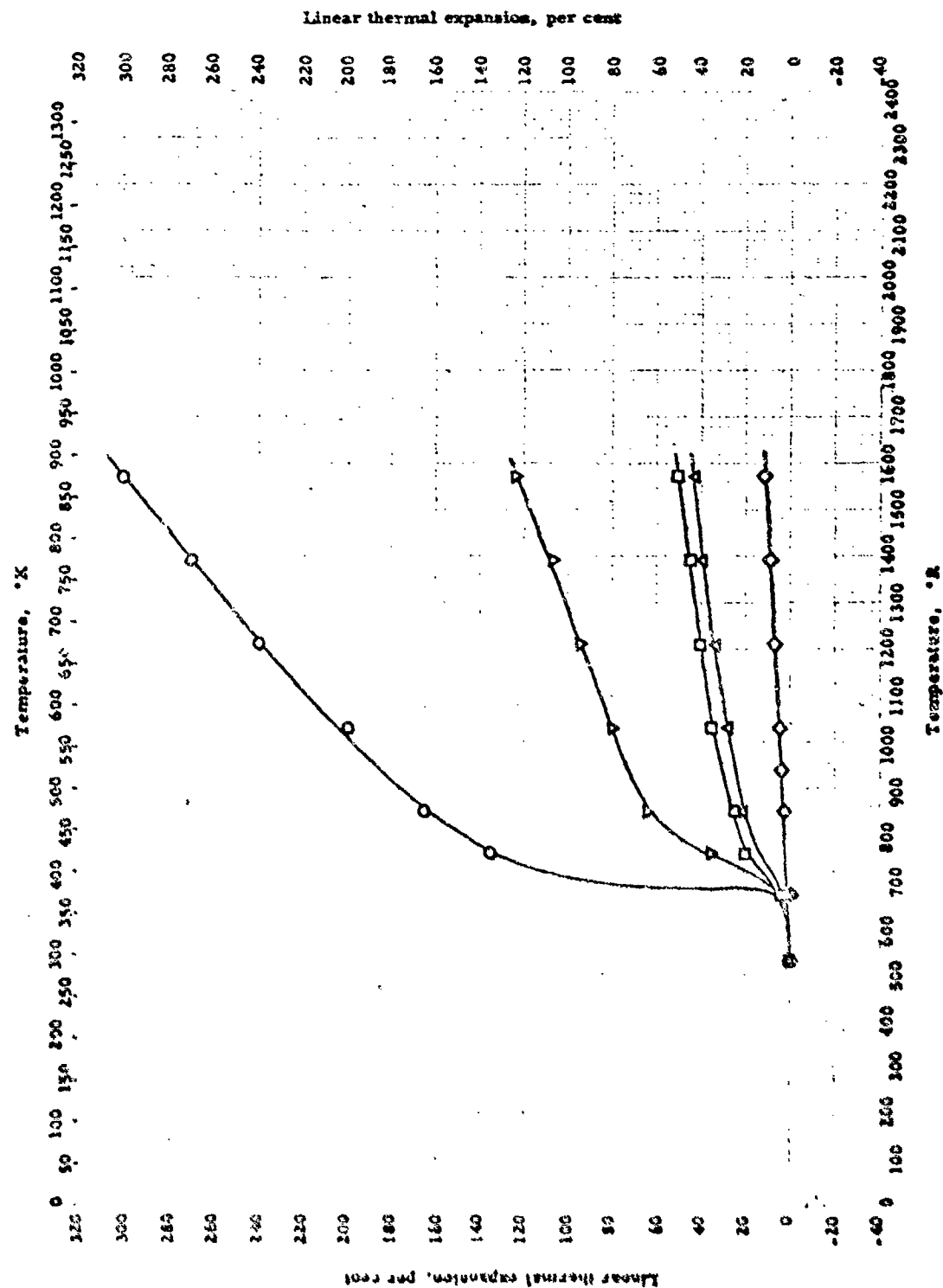
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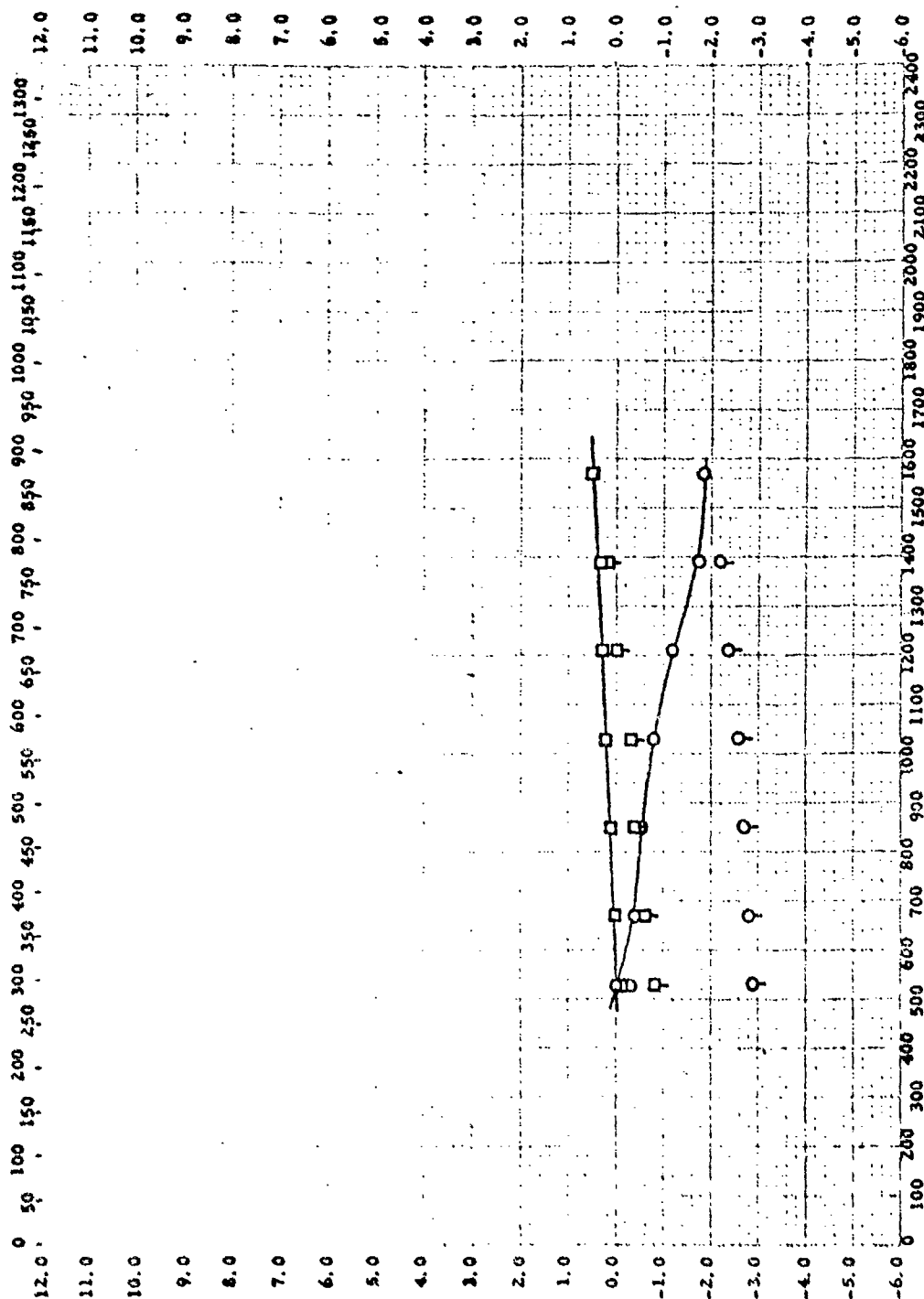
LINEAR THERMAL EXPANSION -- MAGNESIUM MICA (PHLOGOPHITE)

LINEAR THERMAL EXPANSION -- MAGNESIUM MICA (PHLOGOPHITE)*

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
45-2	Edgert, P. and Diana, G.	45-2	528-1572	From Burgess, Canada	Fused quartz dilatometer	Measured perpendicular to cleavage plane; 1 psi compressive load; max. values are shown
45-2	Id.	45-2	528-1572	Same as above	Same as above	Same as above with 30 psi compressive load
45-2	Id.	45-2	528-1572	From Madagascar, Block No. 995	Same as above	Measured perpendicular to cleavage plane; formed from 30 disks; 3rd heating
45-2	Id.	45-2	528-1572	From same sample as above	Same as above	Same as above; one solid disk; 1st heating
45-2	Id.	45-2	528-1572	Same material as above	Same as above	Measured perpendicular to cleavage plane; minimum values are shown
*The above data are representative; for additional information, see original article, 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples						

Temperature, °K



Temperature, °R

LINEAR THERMAL EXPANSION -- POTASSIUM MICA (MUSCOVITE)

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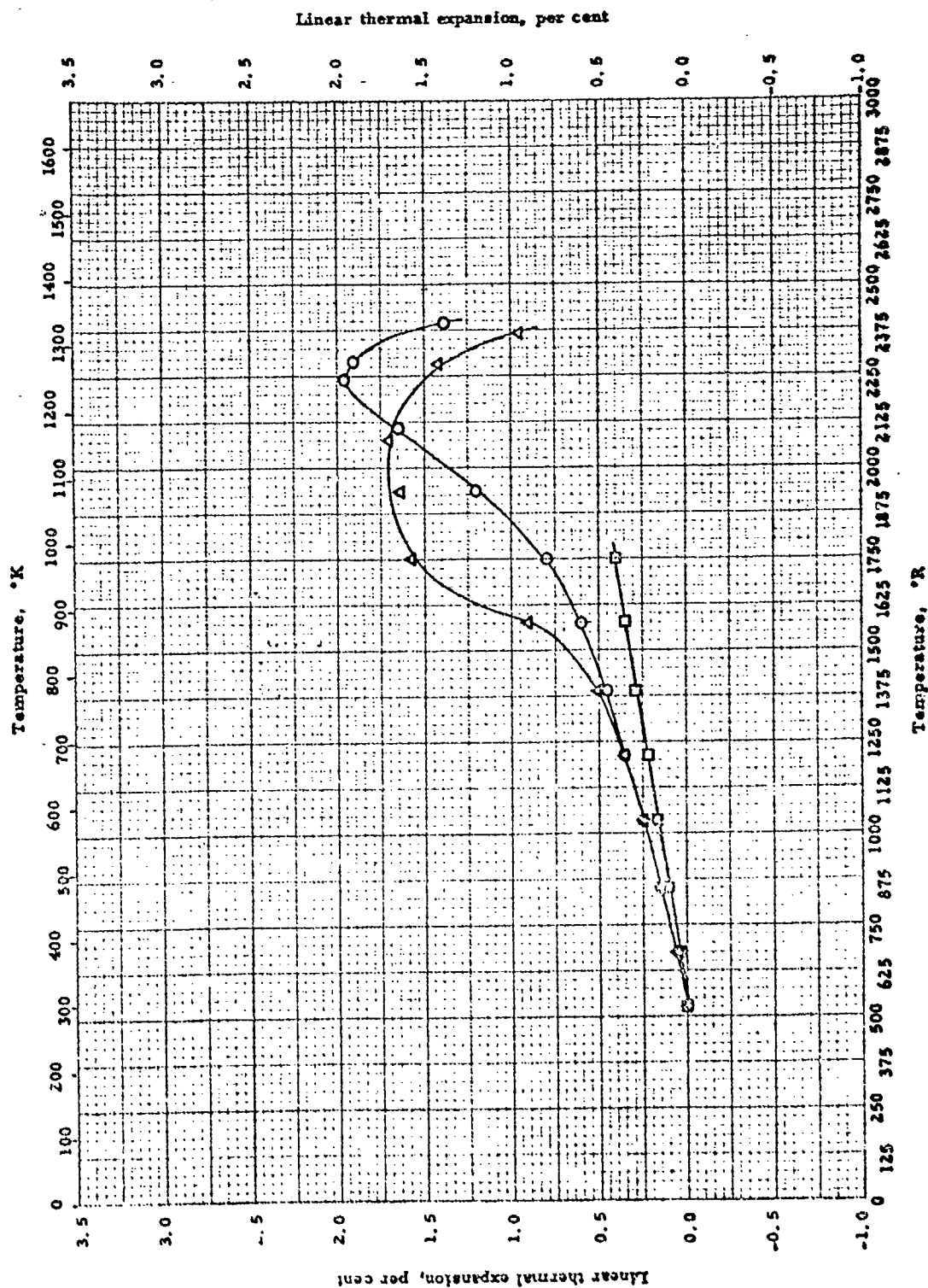
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LINEAR THERMAL EXPANSION -- POTASSIUM MICA (MUSCOVITE)*

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
45-2	Hidvert, P. and Dixon, G.	45-2	528-1572	From Mitchell County, N. C.	Fused quartz dilatometer	Measurements perpendicular to cleavage plane. Q - initial heating; Q - cooling and reheating. Max. in muscovite group
45-2	Ibid.	45-2	528-1572	From Brazil, White 1441 (ruby, first quality)	Same as above	Measurements perpendicular to cleavage plane. Q - initial heating; Q - cooling and reheating. *Above data are representative; for additional information see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples

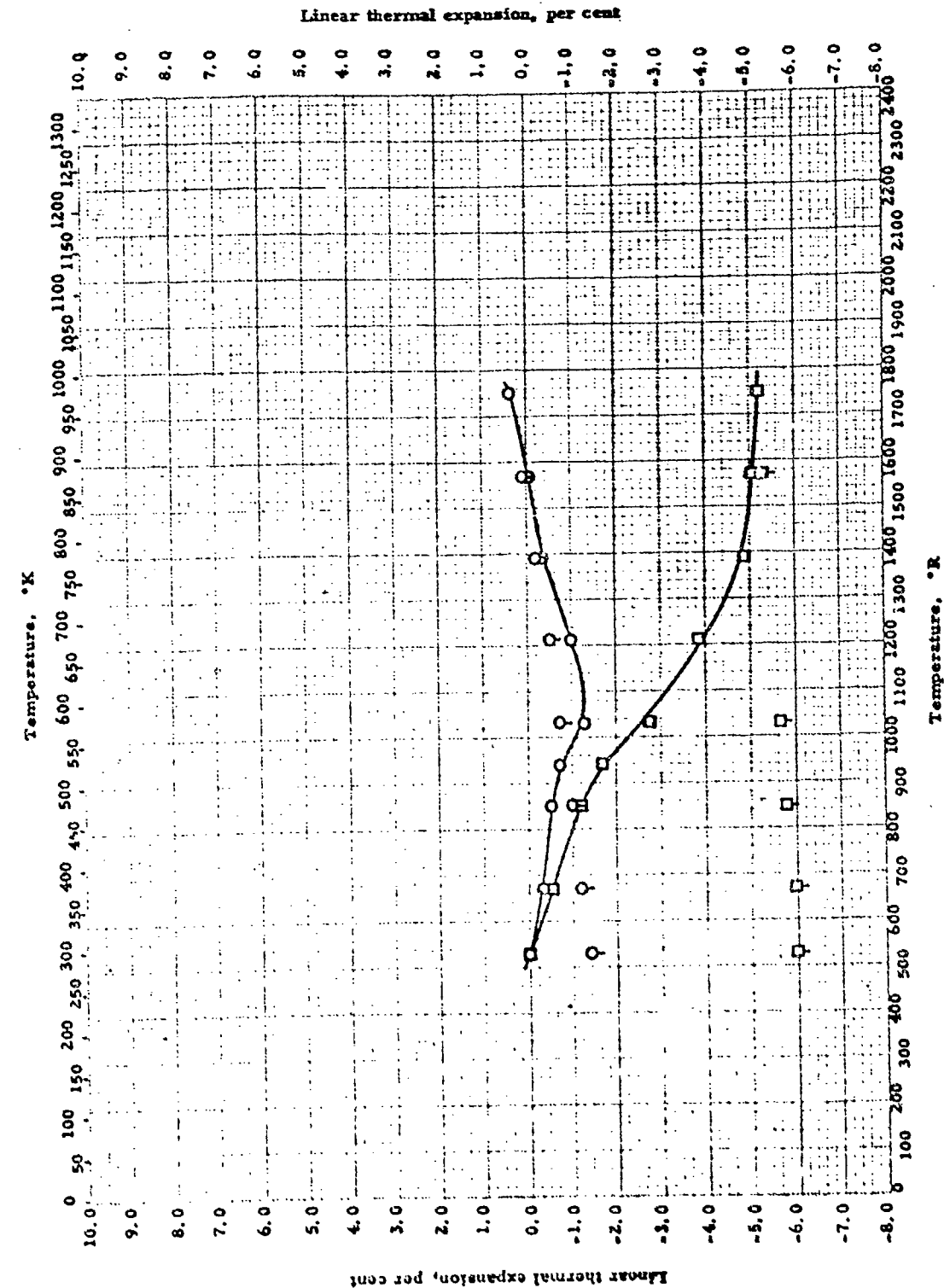


LINEAR THERMAL EXPANSION -- MICA (CERICITE, ILLITE)

LINEAR THERMAL EXPANSION -- MICA (CERICITE, ILLITE)

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Zwetsch, A.	55-21	528-2382	From Le3culou Pyrences Orientales; 50.74% SiO ₂ ; 31.81% Al ₂ O ₃ ; 1.27% Fe ₂ O ₃ ; 0.58% CaO; 0.63% MgO; 10.27% K ₂ O; 0.84% Na ₂ O. Cericite	Dilatometer	Apparently random orienta- tion
□	Ibid.	55-21	528-1752	Above material; fired	Same as above	Loss on firing; 4.07%
Δ	Ibid.	55-21	528-2364	Illite	Same as above	Apparently random orienta- tion



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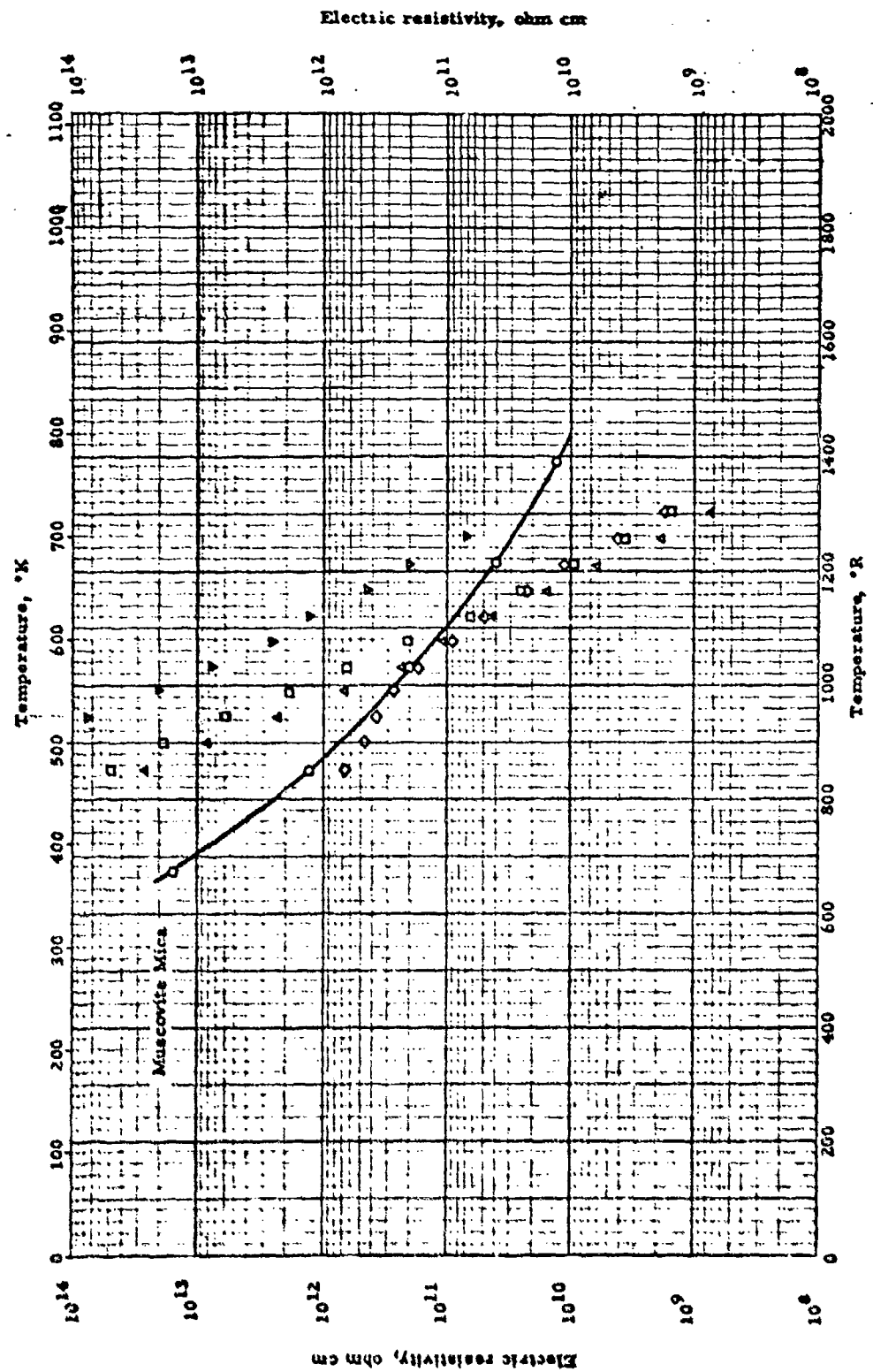
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LINEAR THERMAL EXPANSION -- MICA (RIPIDOLITE and ZINN WALDITE TYPES)

LINEAR THERMAL EXPANSION -- MICA (RIPIDOLITE and ZINN WALDITE TYPES)*

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hidner, P. and Dixon, G.	45-2	528-1752	Zinn Waldite type from Virginia	Fused quartz dilatometer	Measurements perpendicular to cleavage plane, Q - heating; Q - cooling
□	Ibid.	45-2	528-1752	Ripidolite type from Pennsylvania	Same as above	Measurements perpendicular to cleavage plane, □ - initial heating; □ - cooling and reheating. Above data are representative; for additional information see original article, 1 hr. at 700°C increased room temperature thickness as much as 60% in some samples



ELECTRIC RESISTIVITY--MICA

ELECTRIC RESISTIVITY -- MICA

REFERENCE INFORMATION

	Investigator	Ref.	Range, "R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Richards, L. E. and Moore, D. G.	53-136	672-1932	High grade muscovite mica Thickness = 0.002-0.017 in.	Potential drop. Temp. by Fe-Constant thermocouple, with 10° C/min. rise	Cleaved, dried 24 hr. before test. Polarity reversed every 2 min.
□	Cometoro, J. P. and Hatch, R. A.	54-95	852-1302	Synthetic barium mica	High resistance DC bridge. Temp. rise 3° C/min.	Hot pressed, water absorption <0.1%.
△	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above
◇	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above
▽	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above, but water absorption is 4.6%

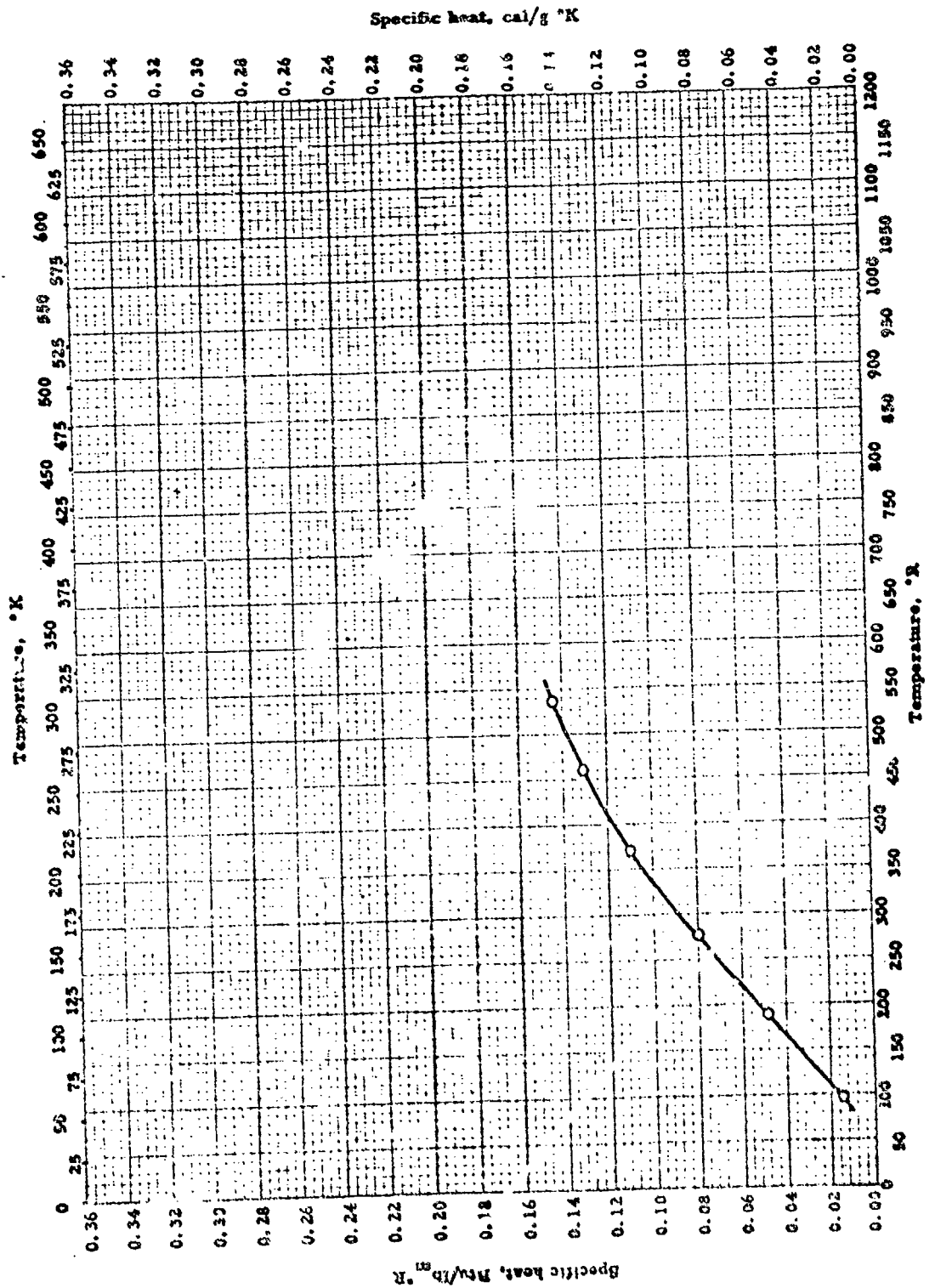
Symbol	Material Composition	Melting Point	
		°K	°K
○	Li ₂ UO ₄	2950 ± 18	1638 ± 10
□	Na ₂ UO ₄	3430 ± 18	1908 ± 10
△	K ₂ UO ₄	3410 ± 18	1893 ± 10
◇	MgUO ₄	3640 ± 45	2023 ± 25
▽	MgUO ₄	3550 ± 45	1973 ± 25
○	MgUO ₄	3260 ± 45	1813 ± 25
○	CaUO ₄	3730 ± 18	2070 ± 10
○	CaUO ₄	3730 ± 18	2070 ± 10
○	CaUO ₄	3400 ± 63	1888 ± 35
○	SrUO ₄	3730 ± 45	2070 ± 25
△	SrUO ₄	3470 ± 18	1928 ± 10
○	SrUO ₄	2890 ± 45	1608 ± 25
○	BaUO ₄	3110 ± 18	1730 ± 10
○	2 NaO · UO ₃ · P ₂ O ₅	about 2196	about 1220
○	UC ₂ · P ₂ O ₅	about 2750	about 1530

MELTING POINT -- URANATES

MELTING POINTS -- URANATES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2730 ±18	V_2UO_4	MP: not given	In air medium
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2430 ±18	Na_2UO_4	MP: same as above	Same as above
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2410 ±18	K_2UO_4	MP: same as above	Same as above
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2400 ±15	$MgUO_4$	MP: same as above	In air medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2350 ±15	$MgUO_4$	MP: same as above	In O_2 medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2280 ±15	$MgUO_4$	MP: same as above	In He medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2720 ±18	$CaUO_4$	MP: same as above	In air medium
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2730 ±18	$CaUO_4$	MP: same as above	In O_2 medium
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2400 ±15	$CaUO_4$	MP: same as above	In He medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2720 ±15	$SrUO_4$	MP: same as above	In air medium, same decomposition
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2470 ±18	$SrUO_4$	MP: same as above	In O_2 medium
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2490 ±15	$SrUO_4$	MP: same as above	In He medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2110 ±18	$BaUO_4$	MP: same as above	In air medium, decomposed
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2196	$2 NaUO_4 \cdot UO_3 \cdot P_2O_5$	MP: same as above	Appears to melt
16-167	Bruck, C. A., Cannon, W. M., and Waller, D. W.	16-167	2726	$UO_3 \cdot P_2O_5$	MP: same as above	Appears to melt

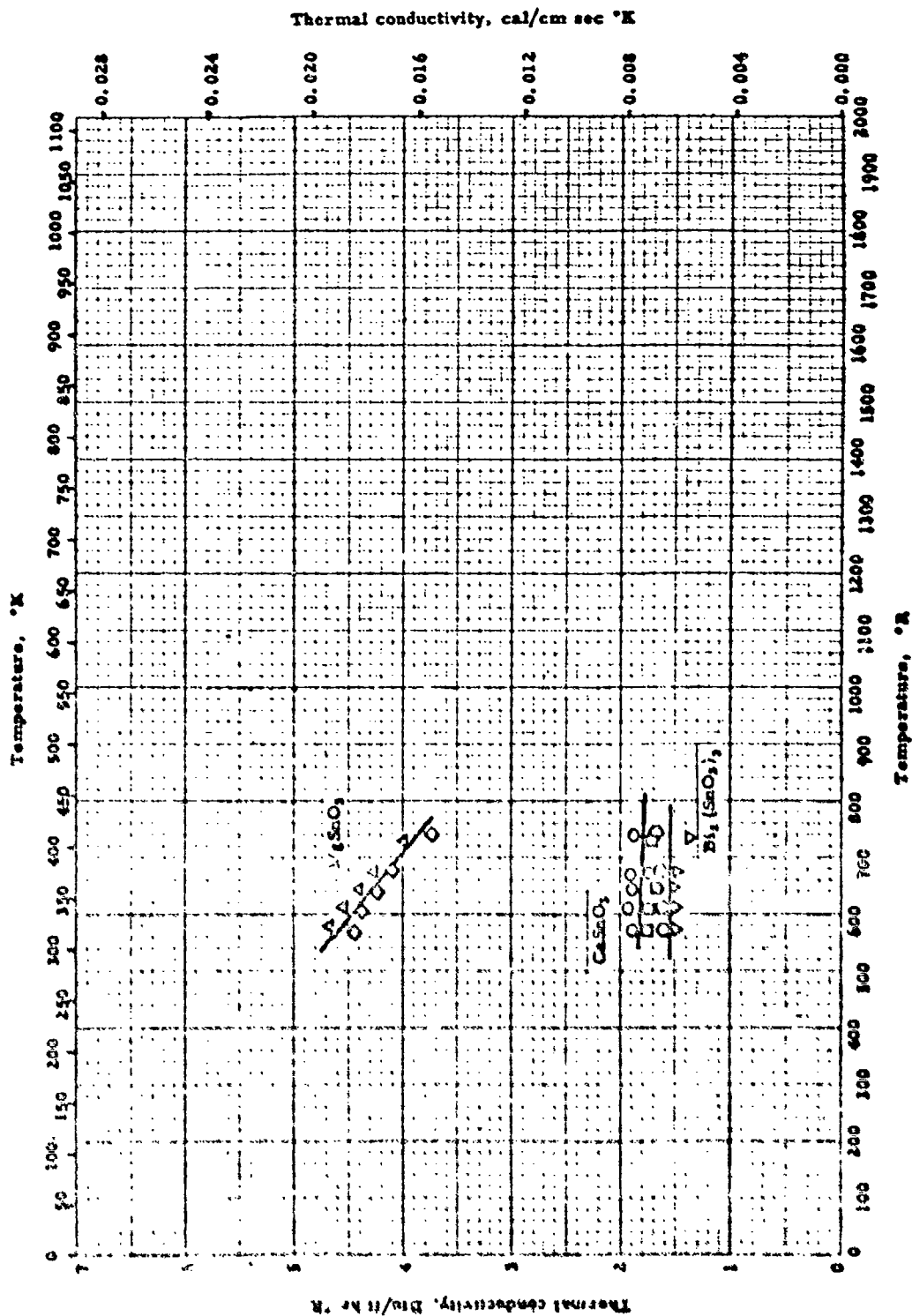


SPECIFIC HEAT - IRON COBALTITE

SPECIFIC HEAT -- IRON COBALTYE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	56-165	96.9-516.7	FeCo ₂ O ₄ Spizel: 49.6% Co (by diff.) 26.88% O; 23.47% Fe (theor.) 26.92% O; 23.49% Fe.	Guarded sample	No uncombined oxides found by x-ray diffraction. During preparation heated 4 times in air for a total of 130 hr. at 1050 °C with grinding mixing etc. between heats



Thermal conductivity -- STANNATES

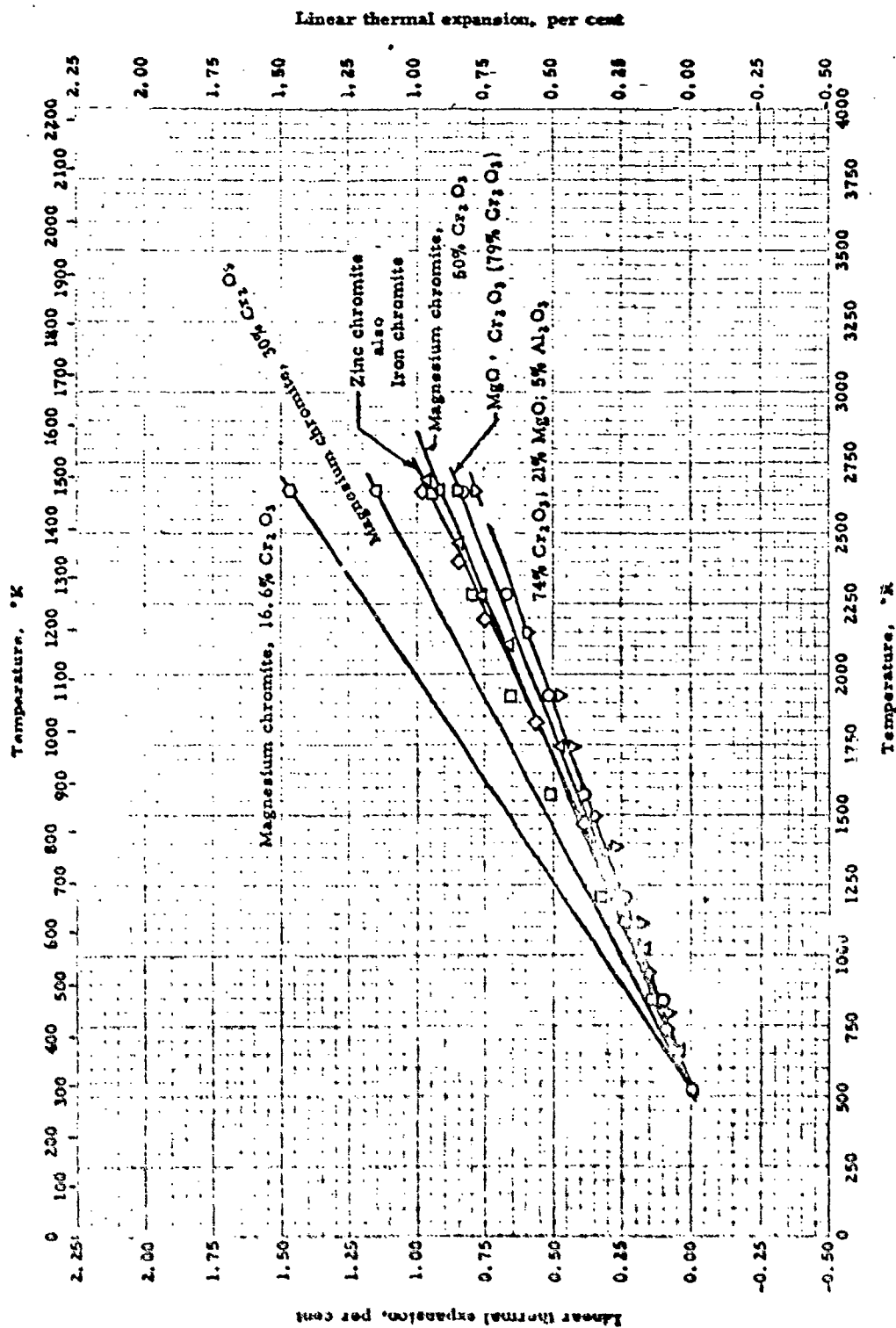
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THERMAL CONDUCTIVITY -- STANNATES

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Kontig, J. H., et al.	53-3	574-740	CaSnO_3 , $\rho = 318 \text{ lb}_m/\text{ft}^3$	Comparative, rod in vacuum (Cu standard)	Used Pt alloy glaze for ceramic to Cu bond, Run I
□	Ibid.	53-3	572-733	Same as above	Same as above	Same as above, Run II
△	Ibid.	53-3	574-730	MgSnO_3 , $\rho = 323 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above, Run I
○	Ibid.	53-3	571-744	Same as above	Same as above	Same as above, Run II
▽	Ibid.	53-3	574-735	$\text{Bi}_2(\text{SnO}_3)_3$, $\rho = 477 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above, Sample #1
○	Ibid.	53-3	574-743	$\text{Bi}_2(\text{SnO}_3)_3$, $\rho = 474 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above, Sample #2

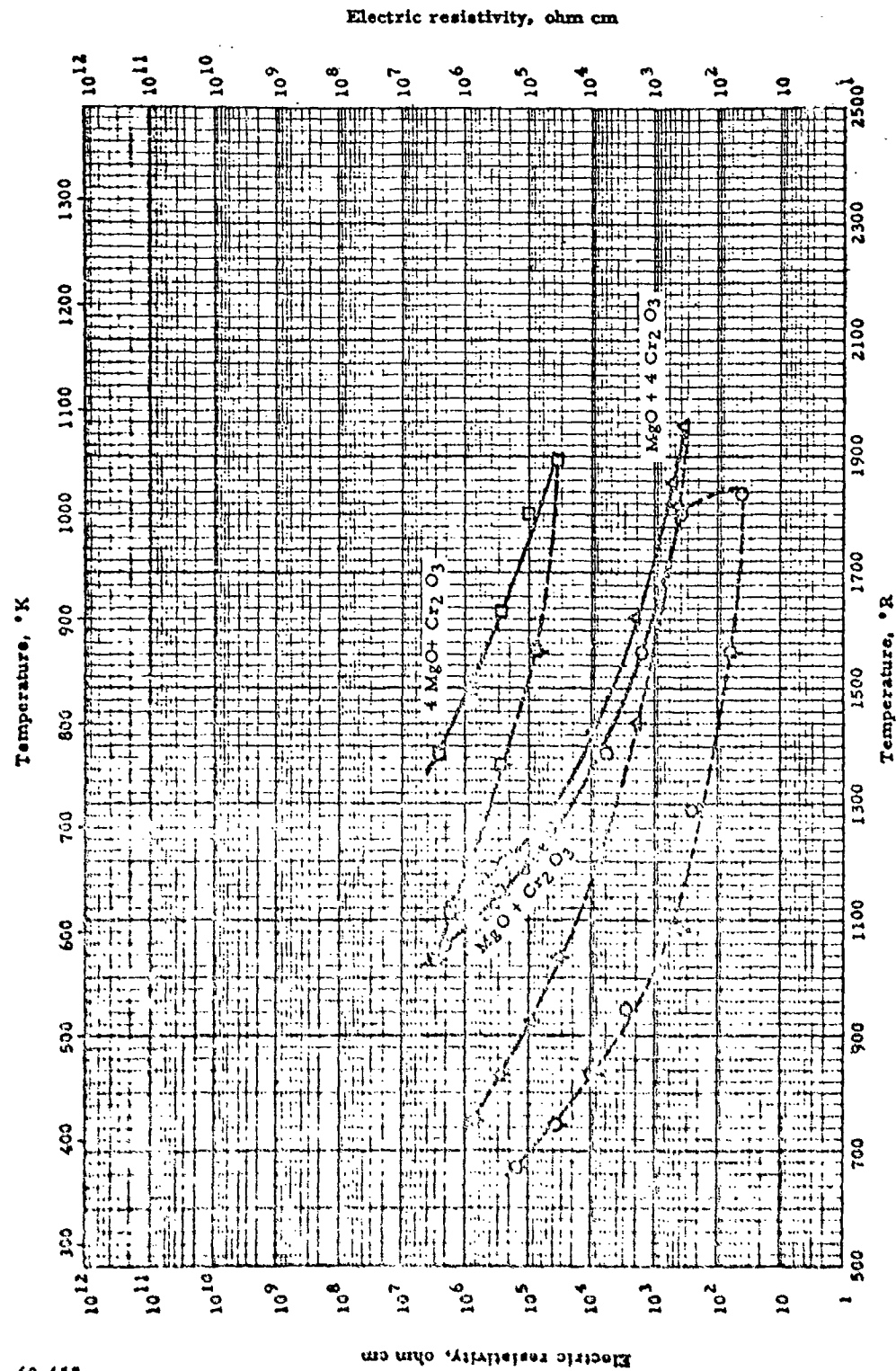


LINEAR THERMAL EXPANSION -- CHROMITE

LINEAR THERMAL EXPANSION -- CHROMITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Pauls, R. J. and Cook, R. L.	57-20	528-2652	Magnesium chromite (spinel)	X-ray back reflection.	Prepared from reagent grade materials
□	Idid.	57-20	528-2652	Zinc chromite (spinel)	Same as above	Same as above
△	Eighty, G. R., Lovell, G. H. B. and Green, A. T.	46-8 also 54-7	670-2650	Picrochromite, $MgCr_2O_4$, $\rho = 274 \text{ lb./ft}^3$	Not given	Oxides mixed with 5% boric acid, molded, fired 2 hr. at 1530 °C, crushed, molded, fired to 1530 °C, crushed, molded, reheated to 1530 °C
◇	Idid.	46-8 also 54-7	670-2650	Solid solution, $Fe_2O_3 \cdot 2 Cr_2O_3$, $\rho = 320 \text{ lb./ft}^3$	Same as above	
▽	Mummel, F. A. and Henry, E. C.	46-13	528-1920	Zinc chromite	Quartz tube dilatometer	
○	Pole, G. R., Seidlich Jr., A. W. and Gilbert, N.	46-14	528-2652	83.4% MgO ; 16.6% Cr_2O_3	Not described here, refers to others. Probably quartz tube dilatometer with dial gauge	Heated at 4 °C/min
○	Idid.	46-14	528-2652	70% MgO ; 30% Cr_2O_3	Same as above	Same as above
○	Idid.	46-14	528-2652	50% MgO ; 50% Cr_2O_3	Same as above	Same as above
○	Idid.	46-14	528-2652	Magnesium chromite, $MgO \cdot Cr_2O_3$; 79% Cr_2O_3 ; 21% MgO	Same as above	Same as above
○	Idid.	46-14	528-2652	74% Cr_2O_3 ; 21% MgO ; 5% Al_2O_3	Same as above	Same as above



ELECTRIC RESISTIVITY -- MAGNESIUM CHROMITE

ELECTRIC RESISTIVITY -- MAGNESIUM CHROMITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Dickens, A. and Doren, J.	55-150	674-1838	MgO + Cr ₂ O ₃	Not described here, re- fers to others	Not sintered. O - heating Q - cooling
□	Ibid.	55-150	1035-1895	4MgO + Cr ₂ O ₃	Same as above	Not sintered. □ - heating □ - cooling
Δ	Ibid.	55-150	756-1955	MgO + 4Cr ₂ O ₃	Same as above	Not sintered. Δ - heating Δ - cooling

<u>Symbol</u>	<u>Material Composition</u>	<u>Softening Point</u>	
		<u>°R</u>	<u>°K</u>
O	75.67% SiO ₂ ; 13.56% Li ₂ O; 9.35% CaO; 0.54% F ₂ ; 0.31% R ₂ O ₃	1378	765
	74.15% SiO ₂ ; 13.45% Li ₂ O; 10.45% CaO; 0.58% R ₂ O ₃	1385	769
	73.95% SiO ₂ ; 13.26% Li ₂ O; 10.50% CaO; 0.69% R ₂ O ₃ ; 0.38% F ₂	1361	756
	73.75% SiO ₂ ; 13.05% Li ₂ O; 9.94% CaO; 2.74% F ₂ ; 0.27% R ₂ O ₃	1302	723
	64.88% SiO ₂ ; 19.20% CaO; 14.59% Li ₂ O; 0.33% R ₂ O ₃	1394	774
	64.54% SiO ₂ ; 25.42% CaO; 9.35% Li ₂ O; 0.36% R ₂ O ₃	1462	812
	49.39% SiO ₂ ; 35.42% CaO; 14.58% Li ₂ O	1397	776

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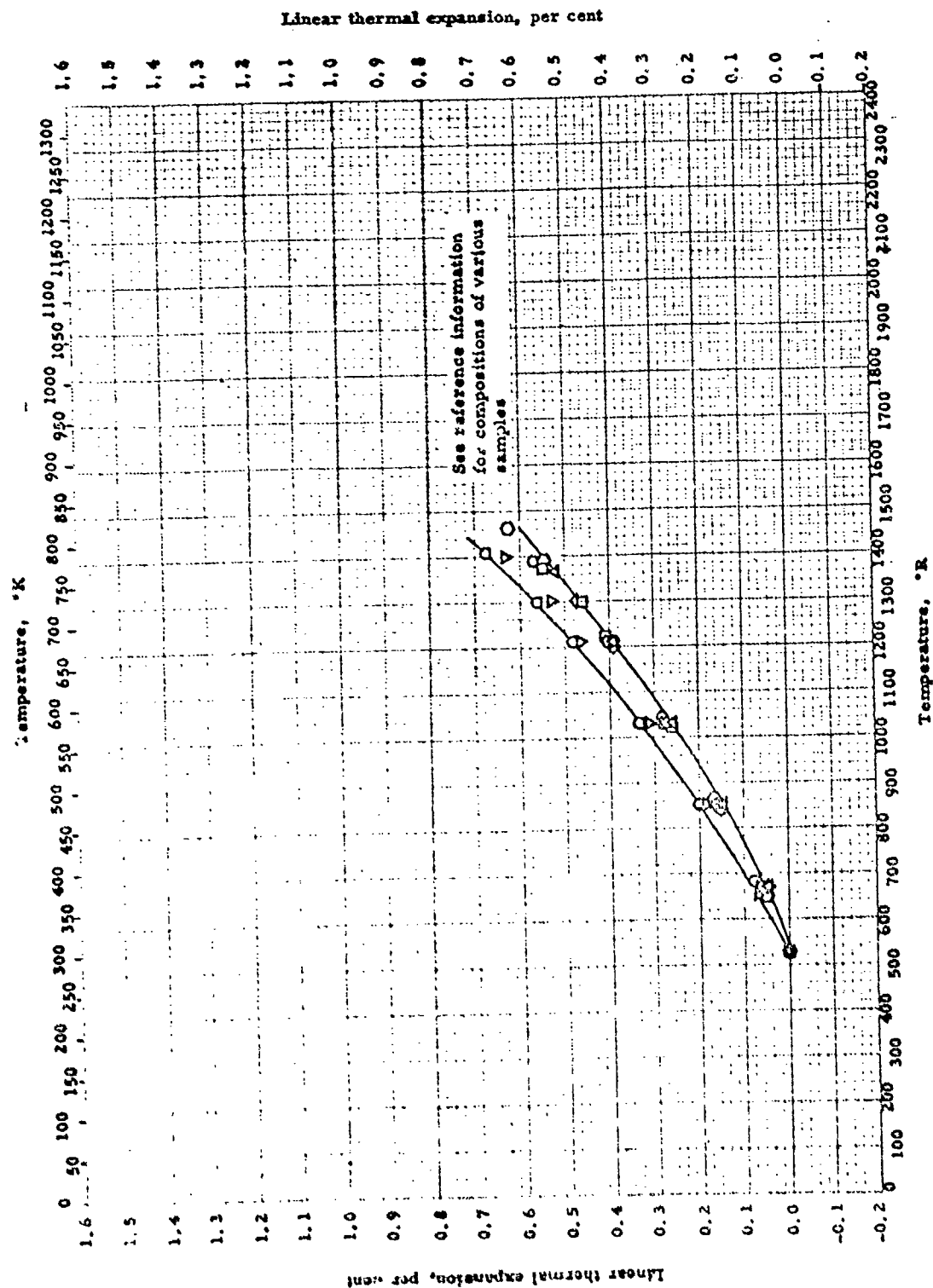
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SOFTENING POINT -- LITHIUM CALCIUM SILICATE GLASS

SOFTENING POINT -- LITHIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Handwerk, J. H. and McVay, T. N.	54-44	1362-1462	49.39 - 64.54% SiO ₂ ; 9.35 - 35.42% CaO; 0.35 - 14.59% Li ₂ O < 2.74% F ₂ ; < 0.69% R ₂ O ₃	Interferometer	

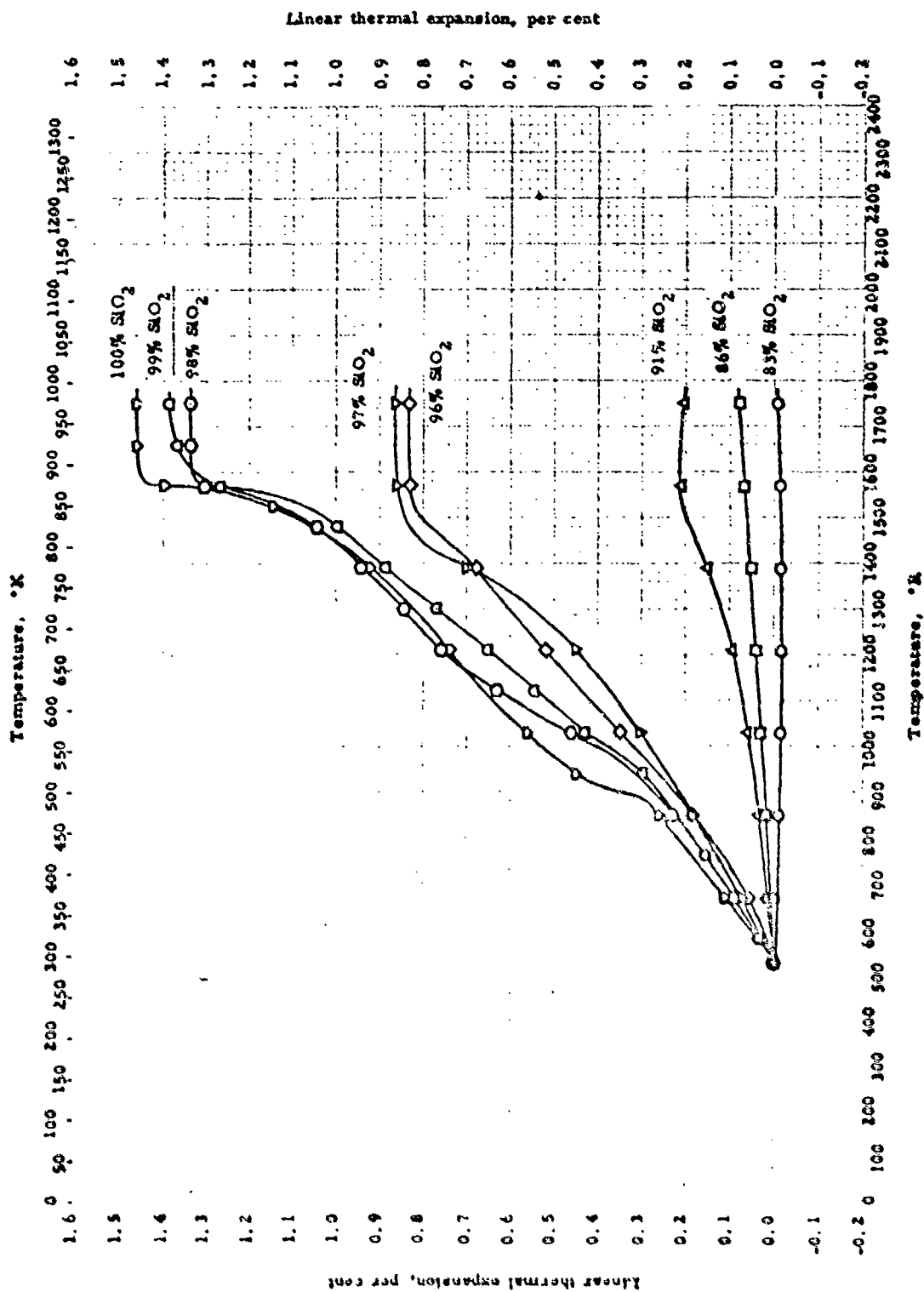


LINEAR THERMAL EXPANSION -- LITHIUM CALCIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O Handwerk, J. H., and McVay, T. N.	54-44	528-1392	75.67% SiO ₂ ; 13.56% Li ₂ O; 9.35% CaO; 0.54% F ₂ ; 0.31% R ₂ O ₃	Interferometer	
Q Ibid.	54-44	528-1374	74.15% SiO ₂ ; 13.45% Li ₂ O; 10.45% CaO; 0.50% R ₂ O ₃	Same as above	
Δ Ibid.	54-44	528-1365	73.95% SiO ₂ ; 13.26% Li ₂ O; 10.50% CaO; 0.69% R ₂ O ₃ ; 0.34% F ₂	Same as above	
○ Ibid.	54-44	528-1352	73.75% SiO ₂ ; 13.05% Li ₂ O; 9.94% CaO; 2.74% F ₂ ; 0.27% R ₂ O ₃	Same as above	
7 Ibid.	54-44	528-1399	64.83% SiO ₂ ; 19.20% CaO; 11.59% Li ₂ O; 0.33% R ₂ O ₃	Same as above	
○ Ibid.	54-44	528-1464	64.54% SiO ₂ ; 25.42% CaO; 9.35% Li ₂ O; 0.36% R ₂ O ₃	Same as above	
○ Ibid.	54-44	528-1406	49.39% SiO ₂ ; 35.42% CaO; 14.58% Li ₂ O; 0.30% R ₂ O ₃	Same as above	

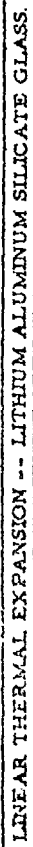


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

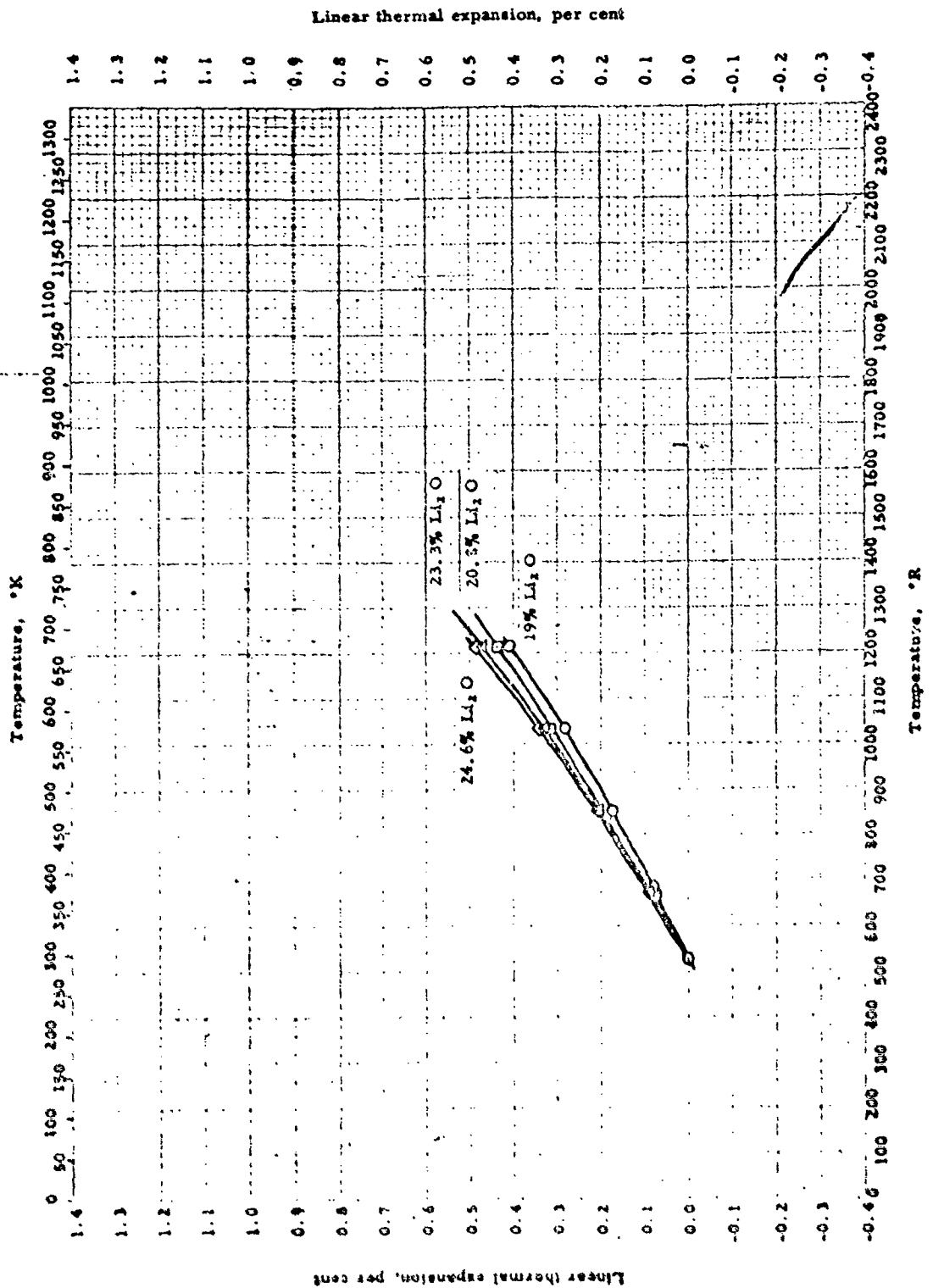
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
34-43	Snake, E. J.	528-1752	83% SiO ₂ ; 12% Al ₂ O ₃ ; 5% Li ₂ O; prepared from E. P. K.; flint; Li ₂ CO ₃	Fused silica tube dilatometer	Fired to 2200°F in 5 hr., soaked 1 hr.
U	ibid.	528-1752	83% SiO ₂ ; 9% Al ₂ O ₃ ; 5% Li ₂ O; raw materials same as above	Same as above	Same as above
Δ	ibid.	528-1752	91% SiO ₂ ; 4% Al ₂ O ₃ ; 5% Li ₂ O; raw materials same as above	Same as above	Same as above
○	ibid.	528-1752	96% SiO ₂ ; 3% Al ₂ O ₃ ; 1% Li ₂ O; raw materials same as above	Same as above	Same as above
○	ibid.	528-1752	97% SiO ₂ ; 2.3% Al ₂ O ₃ ; 0.7% Li ₂ O; raw materials same as above	Same as above	Same as above
○	ibid.	528-1752	93% SiO ₂ ; 1.1% Al ₂ O ₃ ; 0.5% Li ₂ O; raw materials same as above	Same as above	Same as above
○	ibid.	528-1752	94% SiO ₂ ; 0.8% Al ₂ O ₃ ; 0.2% Li ₂ O; raw materials same as above	Same as above	Same as above
○	ibid.	528-1752	100% SiO ₂ ; (Glass)	Same as above	Same as above



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °F.	Material Composition	Test Method	Remarks
51-22	Brackbill, C. E., McKinstry, R. A., and Hummel, P. A.	528-1752	Nominal 47.7% SiO ₂ ; 40.5% Al ₂ O ₃ ; 11.8% Li ₂ O	Interferometer	Li ₂ O · Al ₂ O ₃ · 28SiO ₂
51-22	Idid.	528-1754	Nominal 64.6% SiO ₂ ; 27.4% Al ₂ O ₃ ; 8.0% Li ₂ O	Same as above	Li ₂ O · Al ₂ O ₃ · 48SiO ₂
51-22	Idid.	528-1754	Nominal 73.2% SiO ₂ ; 20.7% Al ₂ O ₃ ; 6.1% Li ₂ O	Same as above	Li ₂ O · Al ₂ O ₃ · 68SiO ₂
51-22	Idid.	528-1754	Nominal 78.5% SiO ₂ ; 16.6% Al ₂ O ₃ ; 4.9% Li ₂ O	Same as above	Li ₂ O · Al ₂ O ₃ · 88SiO ₂
51-22	Idid.	528-1754	Nominal 82.0% SiO ₂ ; 13.9% Al ₂ O ₃ ; 4.1% Li ₂ O Actual 81.54% SiO ₂ ; 14.24% Al ₂ O ₃ ; 4.08% Li ₂ O	Same as above	Li ₂ O · Al ₂ O ₃ · 108SiO ₂

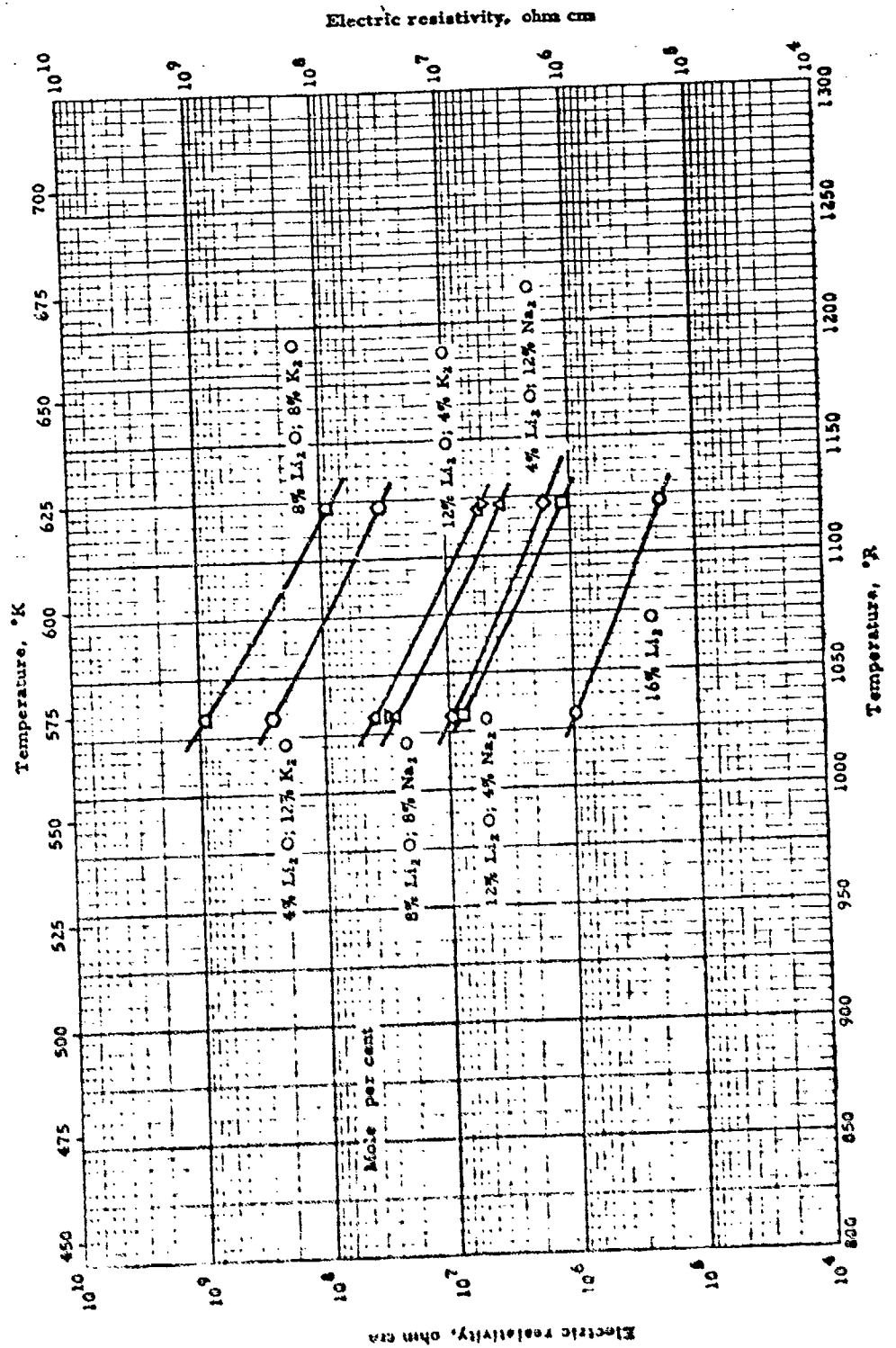


LINEAR THERMAL EXPANSION -- LITHIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sherman, H. F.	56-166	528-1212	81% SiO ₂ ; 19% Li ₂ O. ρ = 145.8 lb _m /ft ³	Interferometer	
□	Did.	56-166	528-1212	79.2% SiO ₂ ; 20.8% Li ₂ O. ρ = 146.6 lb _m /ft ³	Same as above	
△	Did.	56-166	528-1212	76.7% SiO ₂ ; 23.3% Li ₂ O. ρ = 147.0 lb _m /ft ³	Same as above	
◇	Did.	56-166	528-1212	75.4% SiO ₂ ; 24.6% Li ₂ O. ρ = 146.9 lb _m /ft ³	Same as above	



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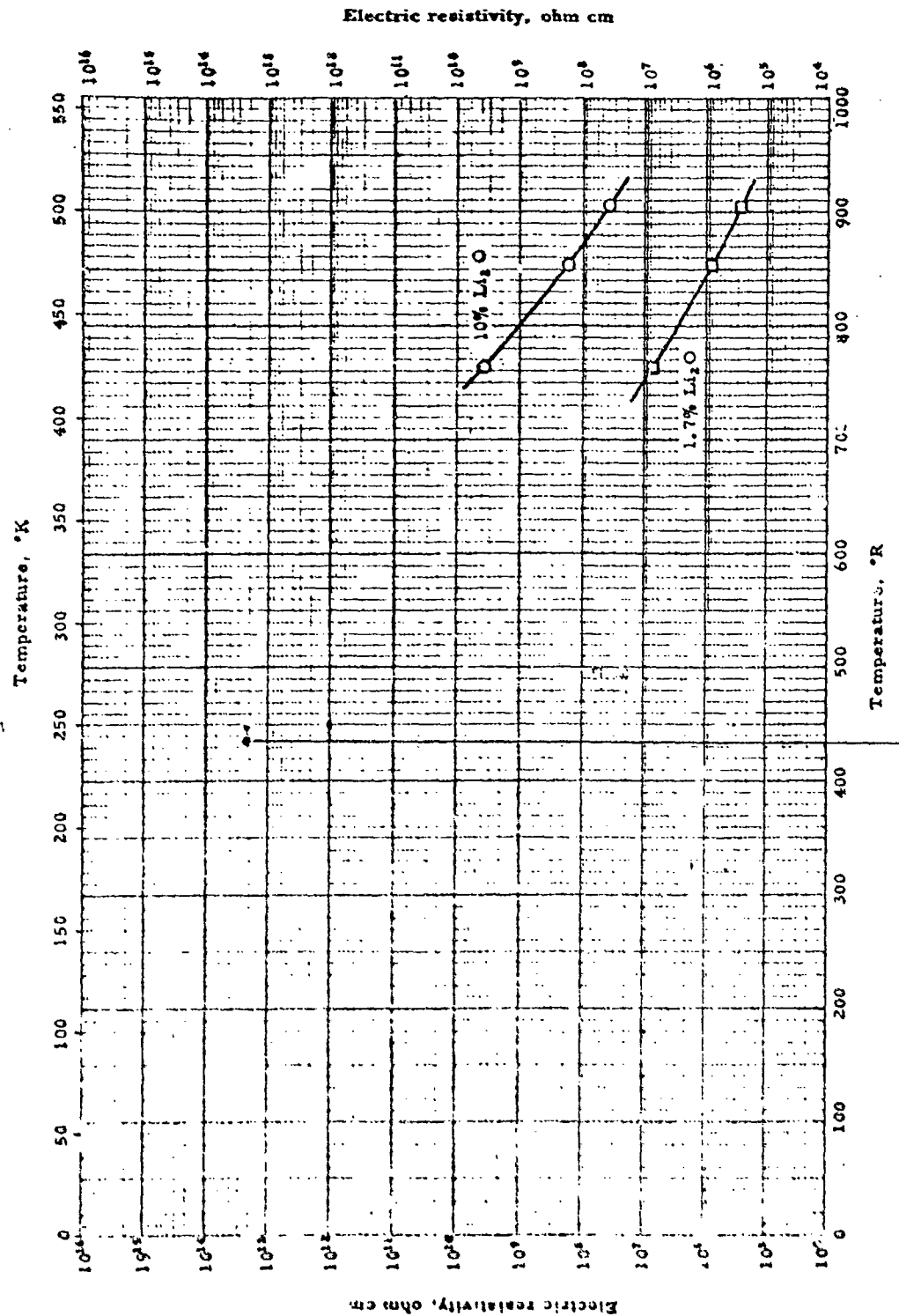
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ELECTRIC RESISTIVITY -- LITHIUM-MAGNESIUM-BARIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-149	Langyel, B. and Eckert, Z.	55-149	1032-1122	68% SiO ₂ ; 16% Li ₂ O; 8% BaO; 8% MgO (mole %)	AC bridge; sample temp. by resistance thermometer	Ground from pure ingredients, melted in furnace at 1260 °C, held 8 hr. at 1200 °C. Samples had Pt electrodes fired on ends
55-149	Idid.	55-149	1032-1122	68% SiO ₂ ; 12% Li ₂ O; 8% BaO; 8% MgO; 4% Na ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	69% SiO ₂ ; 8% BaO; 8% Li ₂ O; 8% MgO; 8% Na ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	68% SiO ₂ ; 12% Na ₂ O; 8% BaO; 8% MgO; 4% Li ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	68% SiO ₂ ; 14.1% K ₂ O; 8% BaO; 8% MgO; 1.9% Li ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	68% SiO ₂ ; 12% K ₂ O; 8% BaO; 8% MgO; 4% Li ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	65% SiO ₂ ; 8% BaO; 8% MgO; 8% Li ₂ O; 8% K ₂ O (mole %)	Same as above	Same as above
55-149	Idid.	55-149	1032-1122	68% SiO ₂ ; 12% Li ₂ O; 8% BaO; 8% MgO; 4% K ₂ O (mole %)	Same as above	Same as above

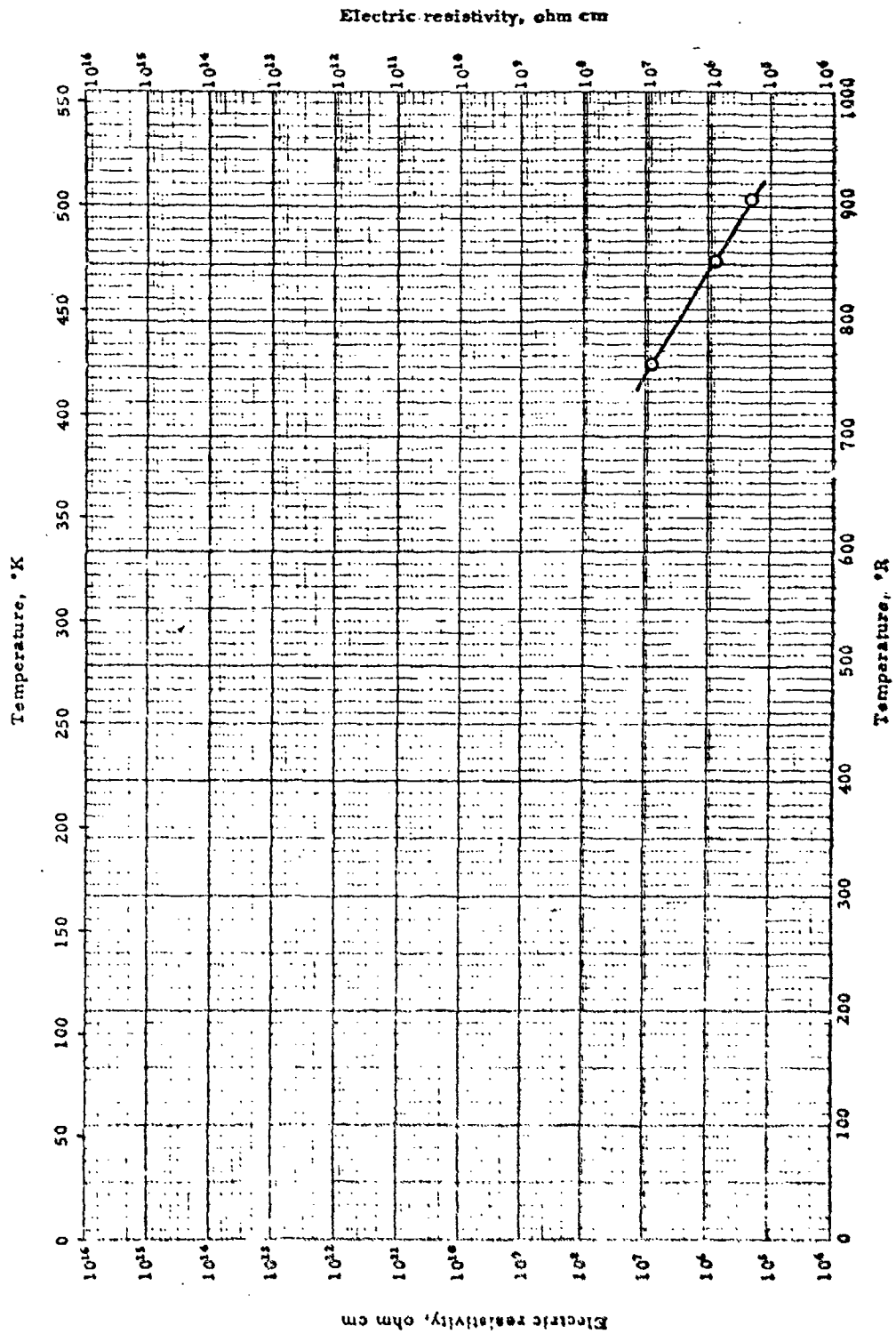


ELECTRIC RESISTIVITY - - LITHIUM SODIUM SILICATE GLASS

ELECTRIC RESISTIVITY - LITHIUM SODIUM SILICATE GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Straness, S. W.	56-163	762-906	73.1% SiO ₂ ; 16.9% Na ₂ O; 10.0% Li ₂ O	Potential drop, D. C. reversal, Fe-Const. thermocouple	Made from reagent grade materials
□	Ibid.	56-163	762-906	67.1% SiO ₂ ; 31.2% Na ₂ O; 1.7% Li ₂ O	Same as above	Same as above. Auth. reports additional detailed data for system (0 to 1.00) Li ₂ O:(1.00 to 0)Na ₂ O: 2SiO ₂ . Only extreme values are shown here



ELECTRIC RESISTIVITY -- LITHIUM SILICATE GLASS

ELECTRIC RESISTIVITY -- LITHIUM SILICATE GLASS

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Strauss, S. W.	56-163	762-906	80.1% SiO ₂ ; 19.9% Li ₂ O	Potential drop, DC re- versal	Made from reagent grade materials

Symbol	Material Composition, %					Density	
	SiO ₂	Na ₂ O	SrO	Al ₂ O ₃	SO ₃	lbm/ft ³	g/cm ³
O	77.7	13.9	6.1	2.1	0.1	152.87	2.4488
	77.7	13.8	8.2	0.2	0.1	154.54	2.4754
	76.1	15.8	6.1	2.0	0.2	154.03	2.4673
	76.0	15.4	8.1	0.2	0.2	155.79	2.4955
	75.4	14.2	6.1	4.0	0.1	153.84	2.4643
	74.8	17.2	4.0	4.0	0.2	153.07	2.4520
	74.7	17.1	6.0	2.0	0.2	154.81	2.4798
	74.3	15.5	6.1	4.1	0.2	154.67	2.4776
	74.1	17.3	7.9	0.3	0.2	156.76	2.5110
	73.5	14.1	10.0	2.0	0.2	157.67	2.5257
	73.5	13.9	12.0	0.3	0.1	159.64	2.5571
	72.2	15.5	10.1	2.1	0.1	158.92	2.5456
	71.9	15.7	12.2	0.1	0.1	160.92	2.5777
	71.5	14.2	10.0	4.1	0.2	158.44	2.5380
	70.7	17.0	11.9	0.1	0.2	161.48	2.5866
	70.6	17.2	8.0	4.0	0.2	158.30	2.5357
	70.5	17.3	10.1	2.0	0.2	159.62	2.5569
	70.1	15.5	10.1	4.1	0.1	159.46	2.5543
	69.6	14.1	13.9	2.0	0.2	162.84	2.6085
	69.5	14.0	16.0	0.2	0.2	164.76	2.6392
	68.0	15.8	16.0	0.1	0.2	165.97	2.6585
	68.0	15.7	14.0	2.0	0.2	163.86	2.6247
	67.9	14.2	13.9	4.1	0.2	163.34	2.6165
	66.6	17.3	15.6	0.2	0.2	166.60	2.6686
	66.6	17.3	13.6	2.1	0.2	164.57	2.6362
	66.8	17.2	11.7	4.0	0.2	162.68	2.6059
	66.1	15.5	14.0	4.1	0.2	164.37	2.6329

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DENSITY -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

DENSITY -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Spec Dot	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Owens Illinois Glass Co. Research Labs	48-38	Room	Series of glasses	Not given here; refers to earlier work	

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Symbol	Density		Softening Point	
	lb / ft ³ m	g/cm ³	°R	°K
○	95.066	1.5235		
□	94.91	1.521		
△	94.72	1.518		
◇	94.505	1.5145		
▽	94.28	1.511		
○	154.1	2.460		
○	154.3	2.472		
▽	154.2	2.470		
△	154.3	2.472		
○	155.1	2.485		
◇	156.3	2.504		
○			1460	809
○			1640	909

60-778

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PROPERTIES OF SODIUM CALCIUM SILICATE GLASS

PROPERTIES OF SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Temp., °F.	Material Composition	Test Method	Remarks
1	Day, R. M. and Jorgensen, M. E.	75-143	Room	64.8% SiO ₂ ; 21.5% Na ₂ O; 9.7% CaO	p: weight and volume by water displacement	
2	Did.	55-143	Room	68.1% SiO ₂ ; 21.24% Na ₂ O; 9.68% CaO	p: same as above	
3	Did.	75-143	Room	68.6% SiO ₂ ; 23.0% Na ₂ O; 6.45% CaO	p: same as above	
4	Did.	75-143	Room	68.5% SiO ₂ ; 26.8% Na ₂ O; 4.85% CaO	p: same as above	
5	Did.	55-143	Room	68.3% SiO ₂ ; 28.5% Na ₂ O; 1.22% CaO	p: same as above	
6	Standen, J. E. and McVay, T. H.	54-44	1457	64.51% SiO ₂ ; 25.76% Na ₂ O; 8.60% CaO; 0.22% P ₂ O ₅	Softening point is temp. at which elongation of thread under its own weight is 1mm min	
7	Did.	55-44	1637	50.20% SiO ₂ ; 35.59% CaO; 13.67% Na ₂ O; 0.25% P ₂ O ₅	Same as above	
8	Vickary, R. C. and Swilack, E.	57-187	530-537	81.6% SiO ₂ ; 7.08% CaO; 4.88% Na ₂ O; 3.22% MgO; 1.22% P ₂ O ₅ ; 0.26% Fe ₂ O ₃ ; 0.25% Cu + Ni oxide	p: pycnometer with CO ₂ free water	water temp. meas. to 0.1°C
9	Did.	57-187	530-537	Same as above + 0.1% Nd ₂ O ₃	p: same as above	Same as above
10	Did.	57-187	530-537	Same as above + 0.2% Nd ₂ O ₃	p: same as above	Same as above
11	Did.	57-187	530-537	Same as above + 0.5% Nd ₂ O ₃	p: same as above	Same as above
12	Did.	57-187	530-537	Same as above + 1.0% Nd ₂ O ₃	p: same as above	Same as above
13	Did.	57-187	530-537	Same as above + 2.0% Nd ₂ O ₃	p: same as above	Same as above, Auth also gives additional density data for addi- tives of 0.1 - 2.0% of other rare earth oxides

PROPERTIES OF SODIUM SILICATE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	157 lb _m /ft ³	2.52 g/cm ³
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	156.6 ± 0.06	2.509 ± 0.001
□	157.40	2.5213
△	157.52	2.5232
◇	158.16	2.5334

<u>Melting Point:</u>	°F	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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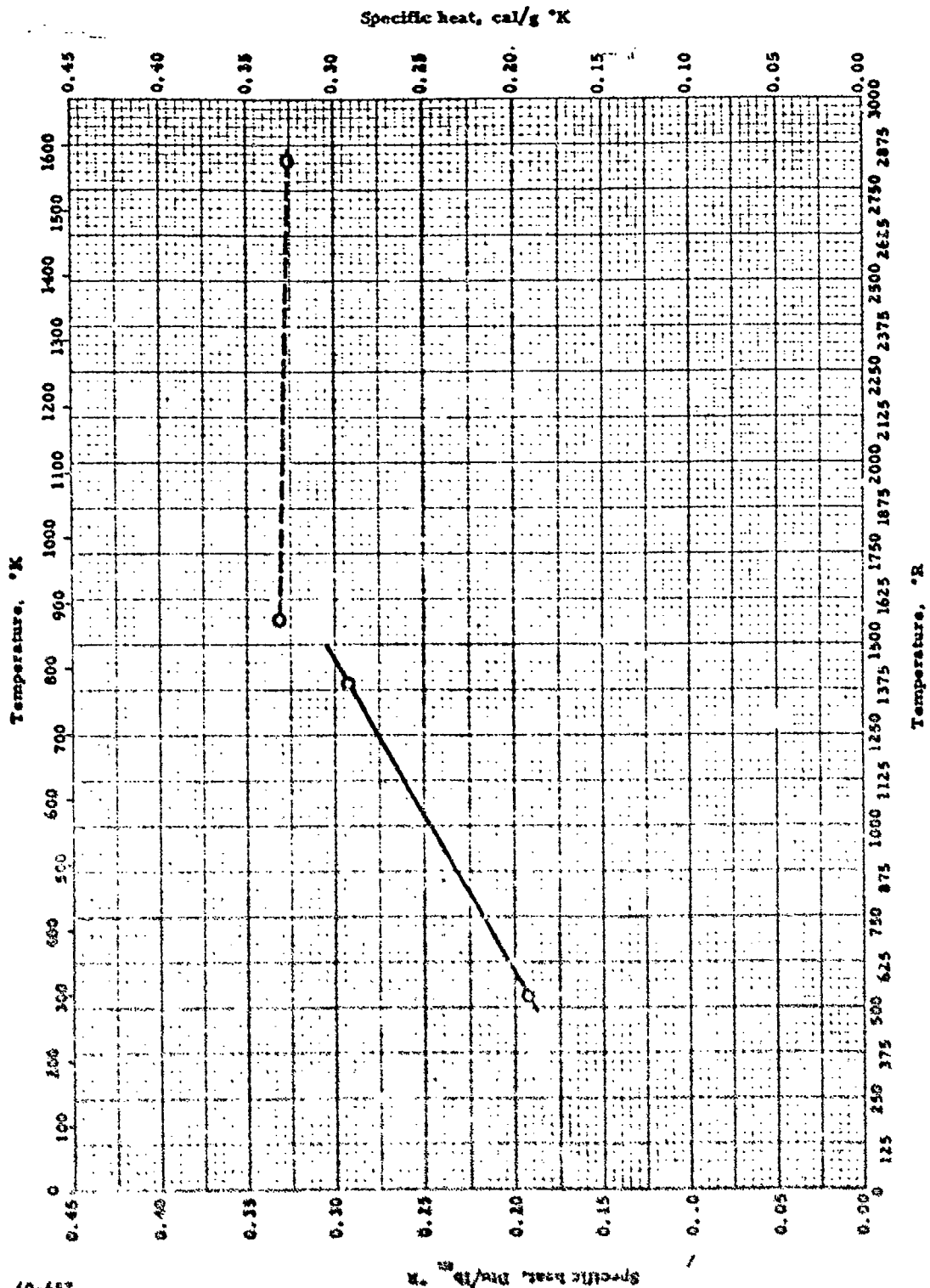
PROPERTIES OF SODIUM SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Pd.	Range, °F.	Material Composition	Test Method	Remarks
○	Oak Ridge National Lab.	57-150	537	Plate glass	p: weight in air and in kerosene	Measured by O. Sieman, C. D. Bopp and R. L. Towne
□	Larkins, C. F. and King, G. F.	52-33 Also 51-65	528	White clear plate glass	p: weight and volume by water displacement	From Pittsburgh Plate Glass Co.
△	Idid.	52-33 Also 51-65	528	Solex "5" plate glass	p: same as above	
◇	Idid.	52-33 Also 51-65	528	Solex 280EX plate glass	p: same as above	

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SPECIFIC HEAT -- SODIUM-CALCIUM SILICATE GLASS

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SPECIFIC HEAT -- SODIUM-CALCIUM SILICATE GLASS

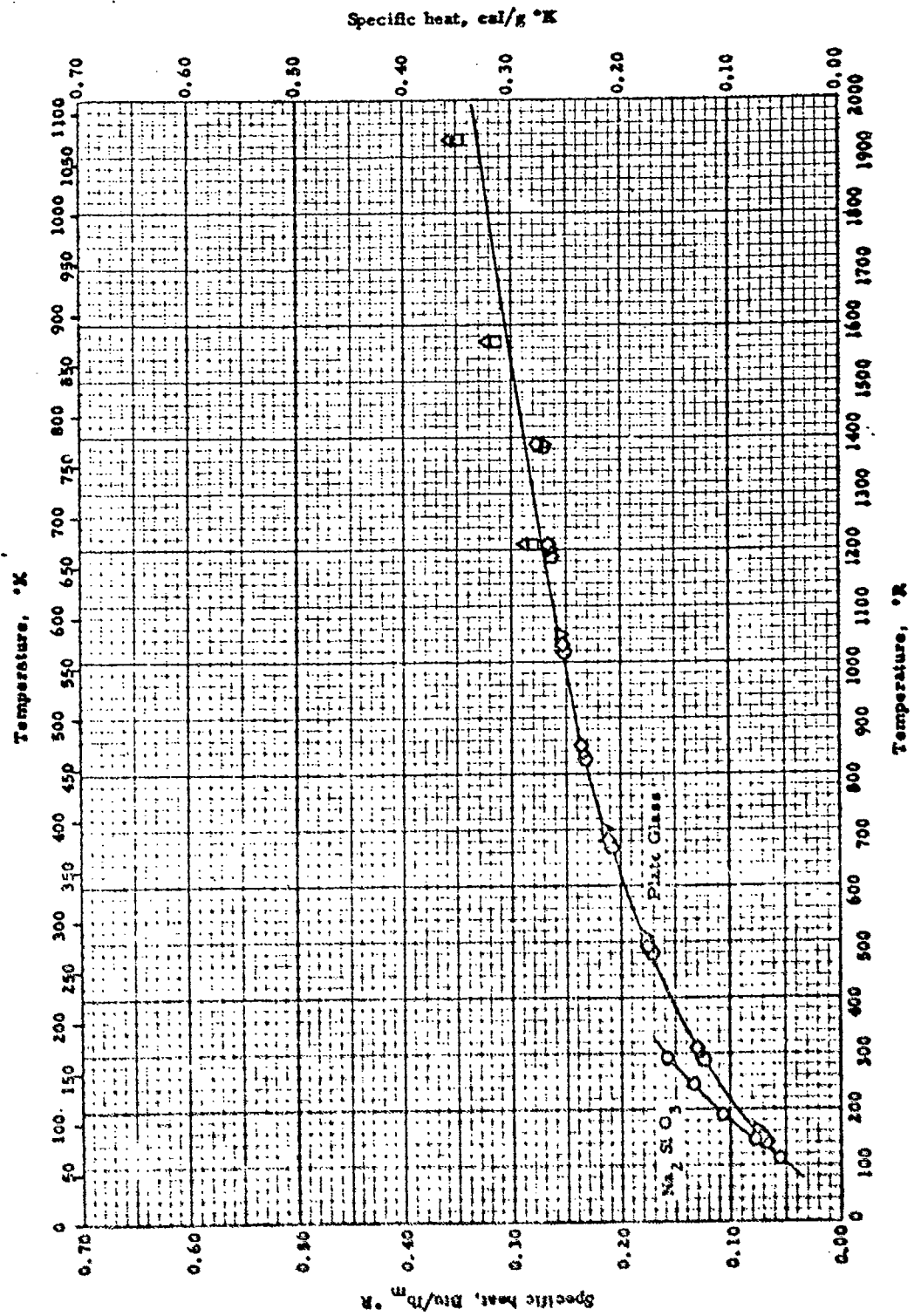
REFERENCE INFORMATION

Sym No	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Hartman, H. and Brand, H.	54-150	528-2832	Brown glass: 72.26% SiO ₂ ; 14.69% Na ₂ O; 9.77% CaO; 1.99% Al ₂ O ₃ ; 1.08% K ₂ O; 0.12% Fe ₂ O ₃ ; trace MgO	Drop method into water calorimeter. Sample temp. meas. by Pt- PtRh thermocouple in furnace	Auth. note sudden enthalpy increase at 550 °C

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SPECIFIC HEAT -- SODIUM SILICATE GLASS

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SPECIFIC HEAT -- SODIUM SILICATE GLASS

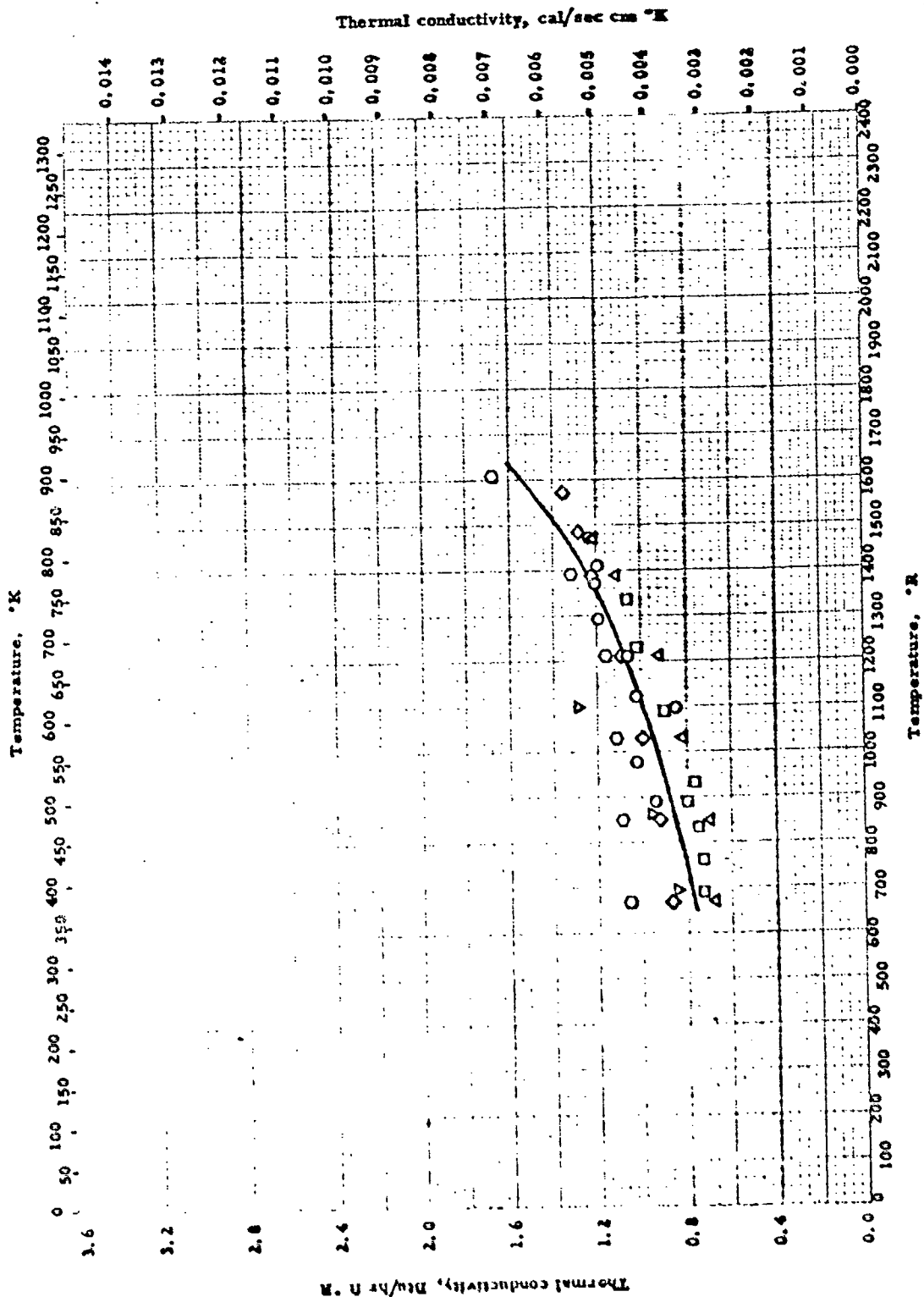
REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
53-64	Tarasev, V. V. and Savitskaya, Ya. S.	110-295	Na_2SiO_3	Guarded sample	
46-7	Anderson, S.	1212-2472	Plate glass: 72% SiO_2 ; 13.7% Na_2O ; 11.5% CaO ; 2.5% MgO ; 0.3% Al_2O_3	Drop method; mercury bath calorimeter	
46-7	Idid.	1212-2472	Solex "S" Glass: same as above with small amount of iron oxide	Same as above	
54-27	Jacks, C. F., Matolich, J., and Van Valzer, J. A.	141-1392	Solex 2808X plate glass	Drop method; ice calorimeter	
54-27	Idid.	141-1392	White clear plate glass	Same as above	
54-27	Idid.	141-1392	Solex "S" glass	Same as above	

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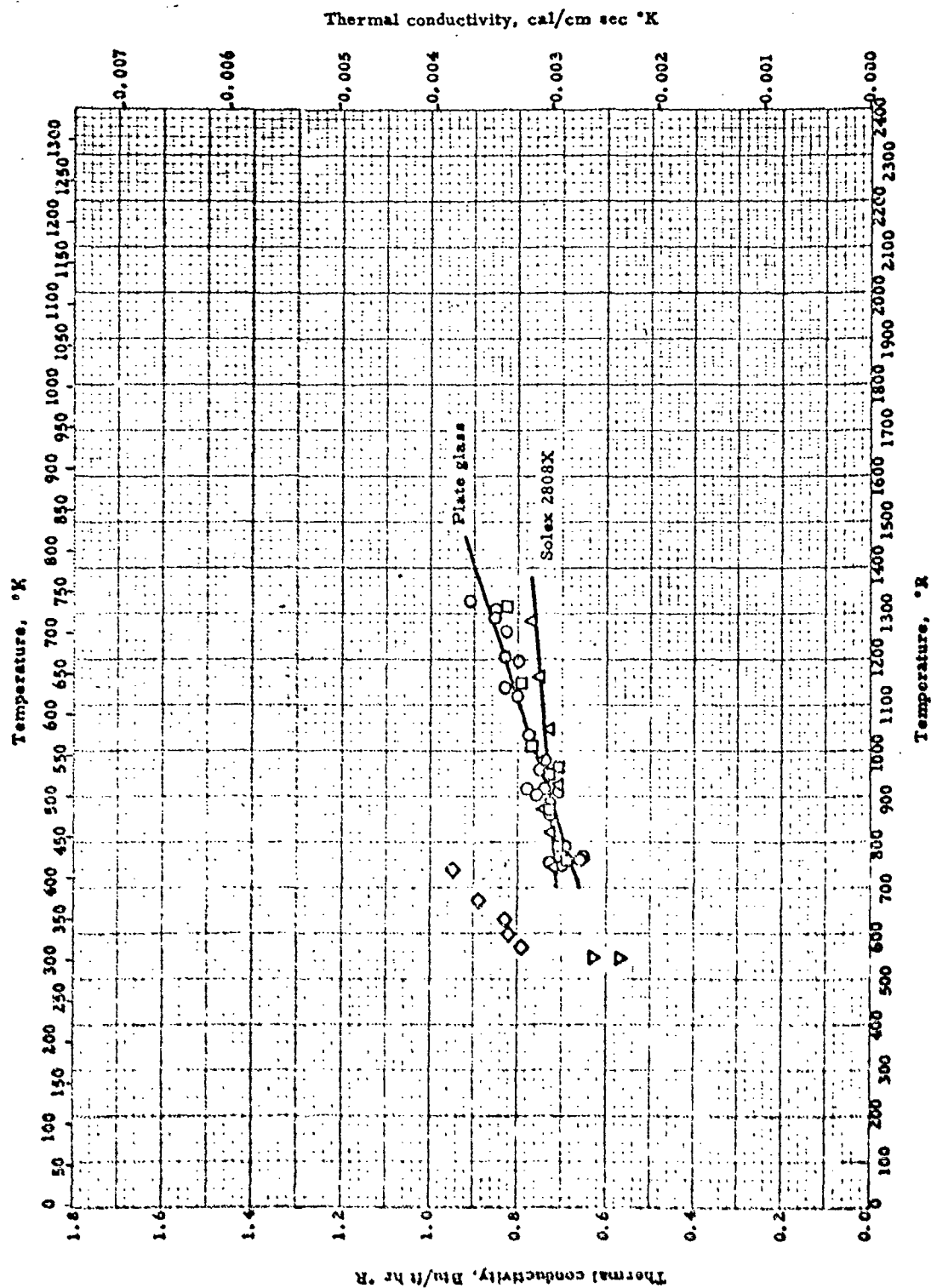


Thermal conductivity -- SODIUM CALCIUM SILICATE GLASS

THERMAL CONDUCTIVITY -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-57	Kingery, W. D. and Norton, F. H.	55-57	888-1473	71.25% SiO ₂ ; 13.35% Na ₂ O; 11.82% CaO; 2.44% MgO; 0.66% Na ₂ SO ₄ ; 0.26% Al ₂ O ₃ ; 0.14% Fe ₂ O ₃ ; 0.06% NaCl	Ellipsoidal envelope	
55-57	Ibid.	55-57	590-1338	Same as above	Comparative; rods	Sample in form of cube
54-64	Kingery, W. D. and Norton, F. H.	54-64	572-1473	70.84% SiO ₂ ; 13.32% Na ₂ O; 11.75% CaO; 2.64% MgO; 0.61% Na ₂ SO ₄ ; 0.56% Fe ₂ O ₃ ; 0.22% Al ₂ O ₃ ; 0.06% NaCl	Comparative; rods	
54-49	Norton, F. H., Kingery, W. D. et al.	54-49	572-1572	Four samples: 58.4-71.3% SiO ₂ ; 13-19.3% Na ₂ O; 6-11.8% CaO; 0.22-7.8% Al ₂ O ₃ ; 0-4.3% K ₂ O; 2.44-3.51% MgO; 0.24-0.68% Na ₂ SO ₄ ; 0.09-0.56% Fe ₂ O ₃ ; 0.06-0.12% NaCl	Ellipsoidal envelope	
43-11	Knaapp, W. J.	43-11	595.4-1100.4	69.73% SiO ₂ ; 20.96% Na ₂ O; 9.03% CaO; 0.18% Al ₂ O ₃ ; trace K ₂ O	Comparative; rods. Chromel-Constantan thermocouples	Sample in form of cube
53-68	Norton, F. H., Kingery, W. D. et al.	53-68	572-1602	Corning No. 0080	Ellipsoidal envelope	



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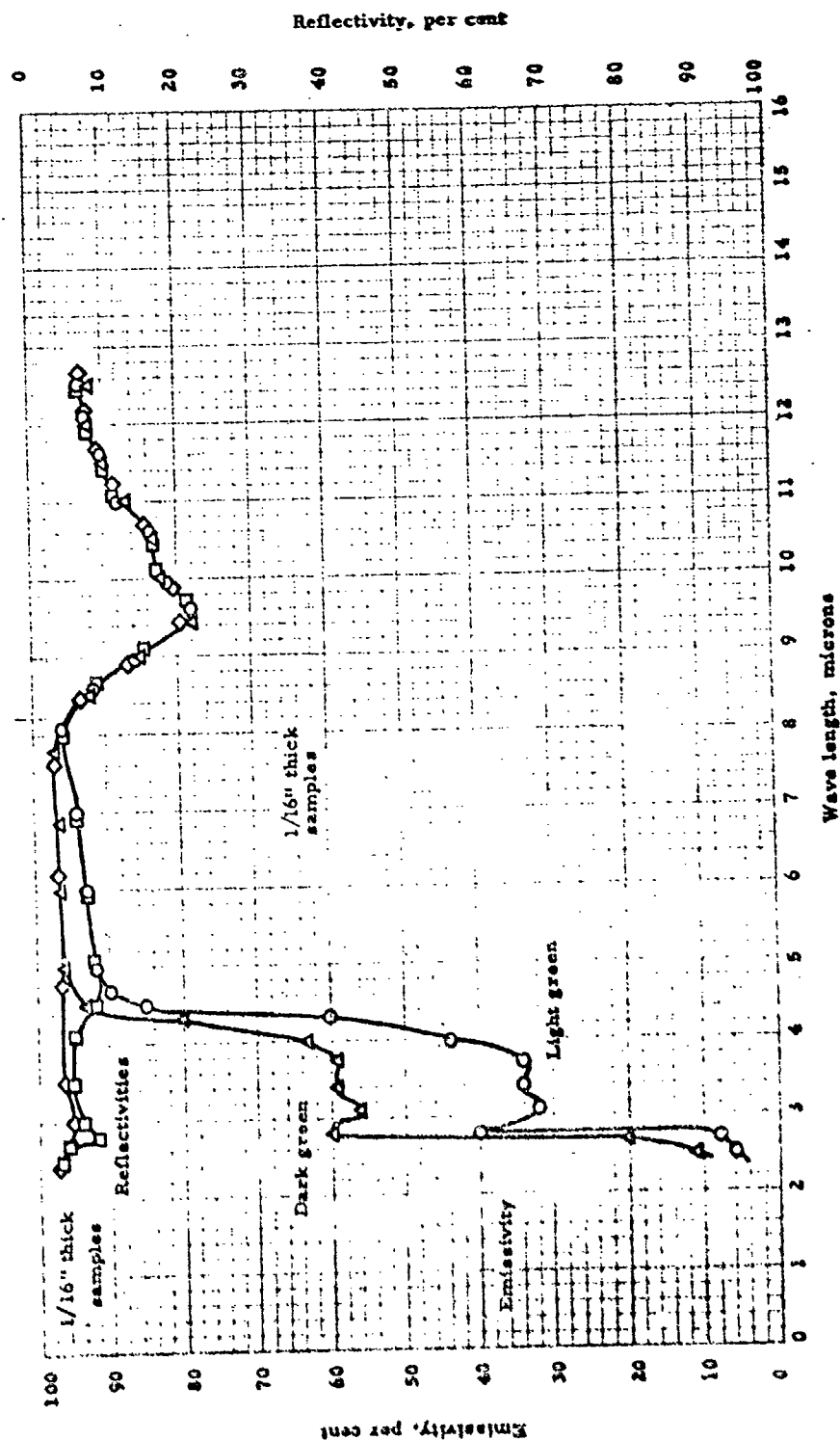
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Thermal conductivity -- SODIUM SILICATE GLASS

THERMAL CONDUCTIVITY -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucka, C. F., Matolich, J. and Van Vactor, J. A.	54-27	755-1325	White clear plate glass	Not described here, refers to others	
□	Ibid.	54-27	758-1316	Solex "S" plate glass	Same as above	
△	Ibid.	54-27	744-1266	Solex 2808X plate glass	Same as above	
◇	Koenig, J. H. and New Jersey Ceramic Research Station	53-43	109.6 - 280.7	Plate glass. $\rho = 156 \text{ lb}_m/\text{ft}^3$	Comparative: rods in vacuum, Inconel standard	
▽	Oak Ridge National Laboratory	57-150	546	Plate glass	Not described here, refers to others	

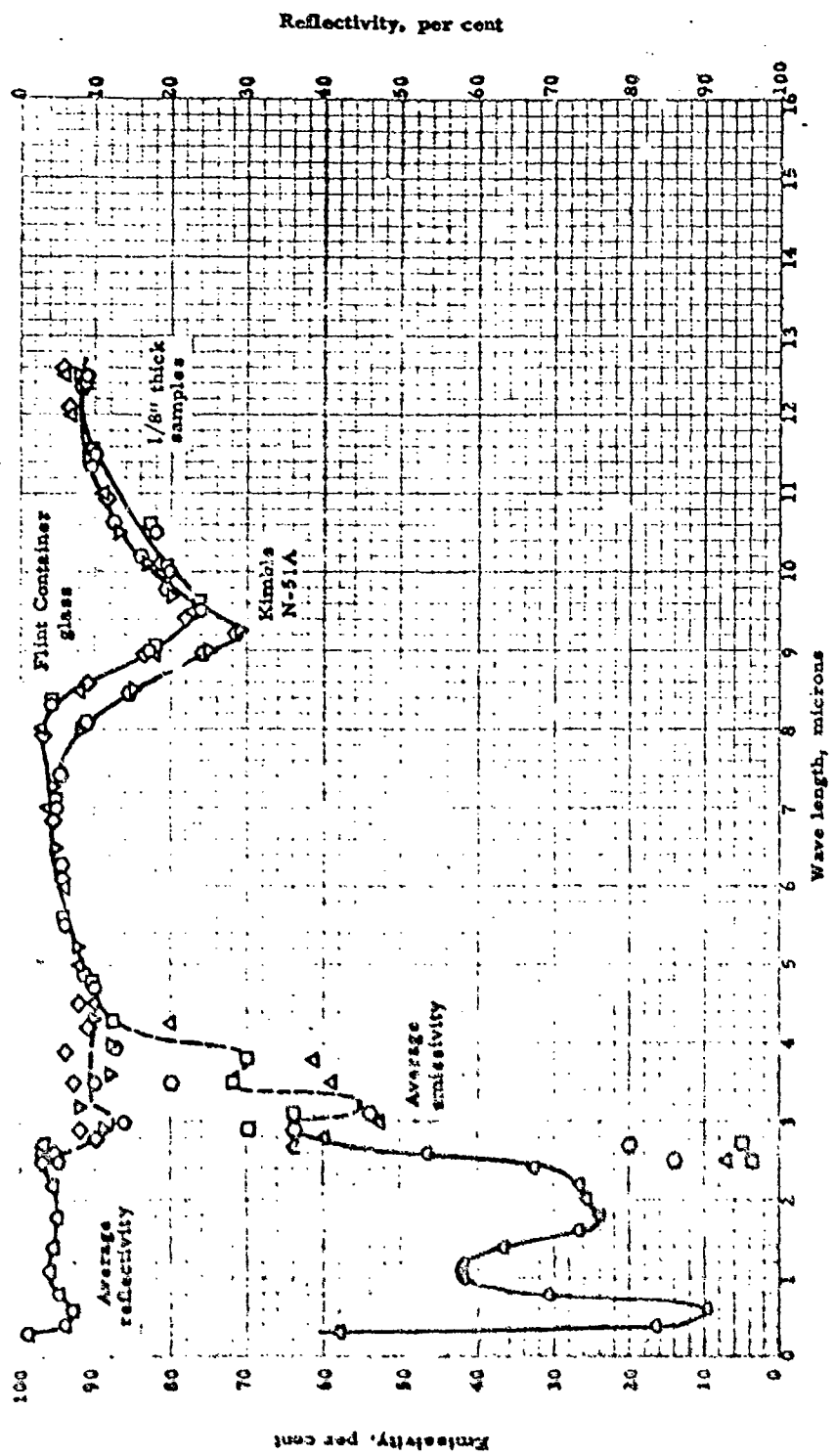


SPECTRAL EMISSIVITY -- GREEN CONTAINER GLASS

SPECTRAL EMISSIVITY -- GREEN CONTAINER GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McMahon, H.	51-80	1460	Light chrome green container glass: 71.0% SiO ₂ ; 13.1% Na ₂ O + K ₂ O; 11.2% CaO; 2.8% MgO; 2.8% MgO; 1.3% R ₂ O ₃ ; 0.6% BaO	Spectral emissivity; Perkin Elmer spectrometer	1/16 in. thick at 1000°R
□	Did.	51-80	1460	Same as above	Spectral reflectivity; computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1 - transmissivity - emissivity
△	Did.	51-80	1460	Dark chrome green container glass: 70.9% SiO ₂ ; 16.6% Na ₂ O + K ₂ O; 6.7% CaO; 3.6% MgO; 3.6% MgO; 1.5% R ₂ O ₃ ; 0.5% BaO	Spectral emissivity; Perkin Elmer spectrometer	1/16 in. thick at 1000°R
◇	Did.	51-80	1460	Same as above. Reflectivity = 1 - transmissivity - emissivity	Spectral reflectivity; computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1 - transmissivity - emissivity



SPECTRAL EMISSIVITY -- SODIUM CALCIUM SILICATE GLASS

SPECTRAL EMISSIVITY -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

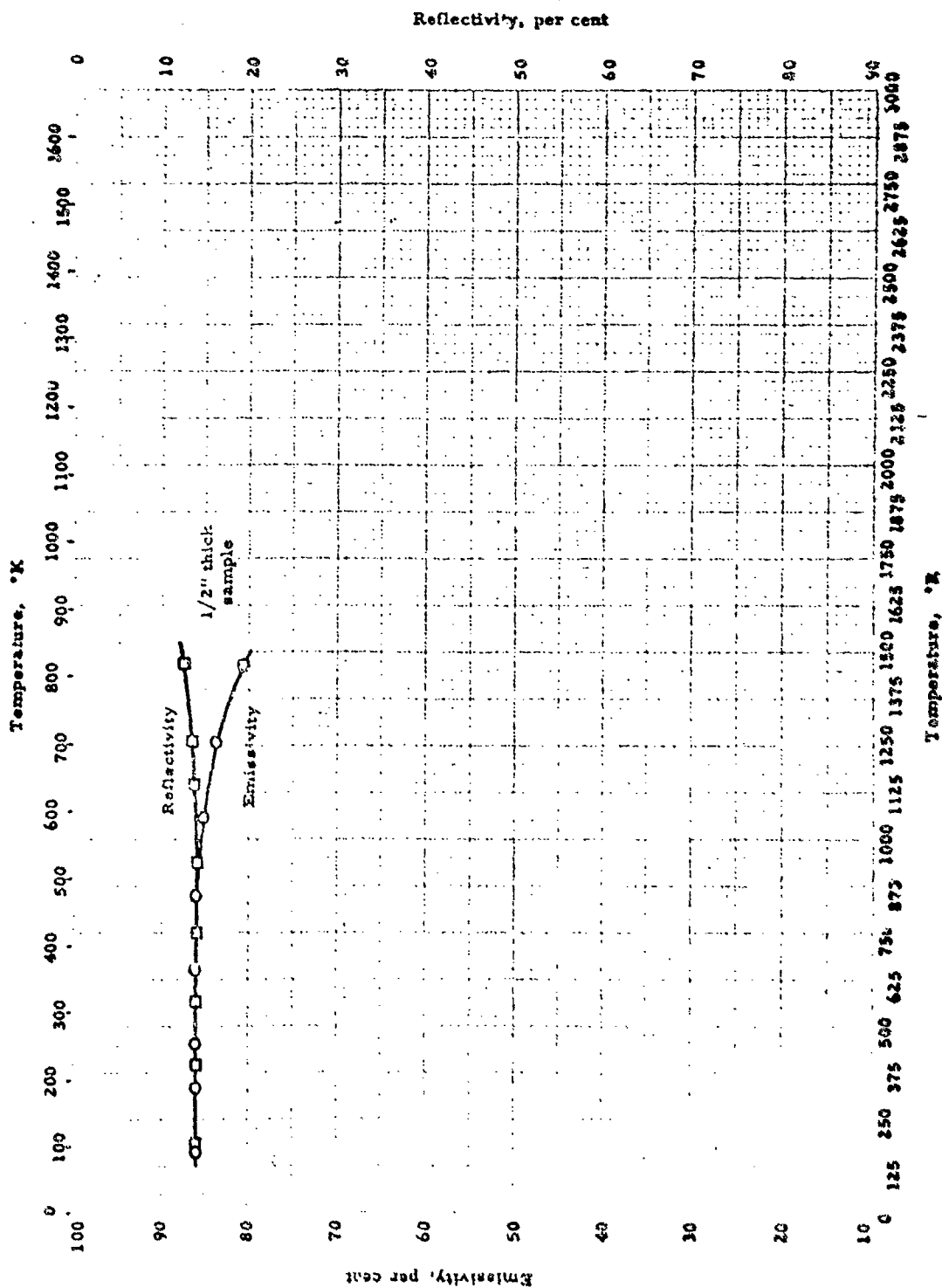
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McMahon, H.	SI-80	1450	Low-iron films glass: 72.2% SiO ₂ ; 13.0% (Na ₂ O and K ₂ O); 12.7% CaO; 1.1% R ₂ O ₃	Spectral reflectivity: computed from measurement of emissivity and transmissivity	1/8 in. thick at 1000°F. Reflectivity = 1-transmissivity-emissivity
○	Did.	SI-80	1450	Same as above	Spectral emissivity: Perkins Elmer spectrometer	1/8 in. thick at 1000°F
○	Did.	SI-80	1450	Thick container glass: 71.7% SiO ₂ ; 13.3% (Na ₂ O and K ₂ O); 11.9% CaO; 1.8% R ₂ O ₃ ; 0.6% BaO; 0.3% MgO	Spectral emissivity: same as above	Same as above
○	Did.	SI-80	1450	Same as above	Spectral reflectivity: same as for ○ above	Reflectivity = 1-transmissivity-emissivity
▽	Did.	SI-80	1450	Glass -- 80 mole N-SiA: 74.7% SiO ₂ ; 9.6% R ₂ O ₃ ; 1.9% (Na ₂ O and K ₂ O); 5.6% R ₂ O ₃ ; 2.3% BaO; 0.9% CaO	Spectral reflectivity: same as above	Same as above
○	Did.	SI-80	1450	Same as above	Spectral emissivity: same as for □ above	1/8 in. thick at 1000°F

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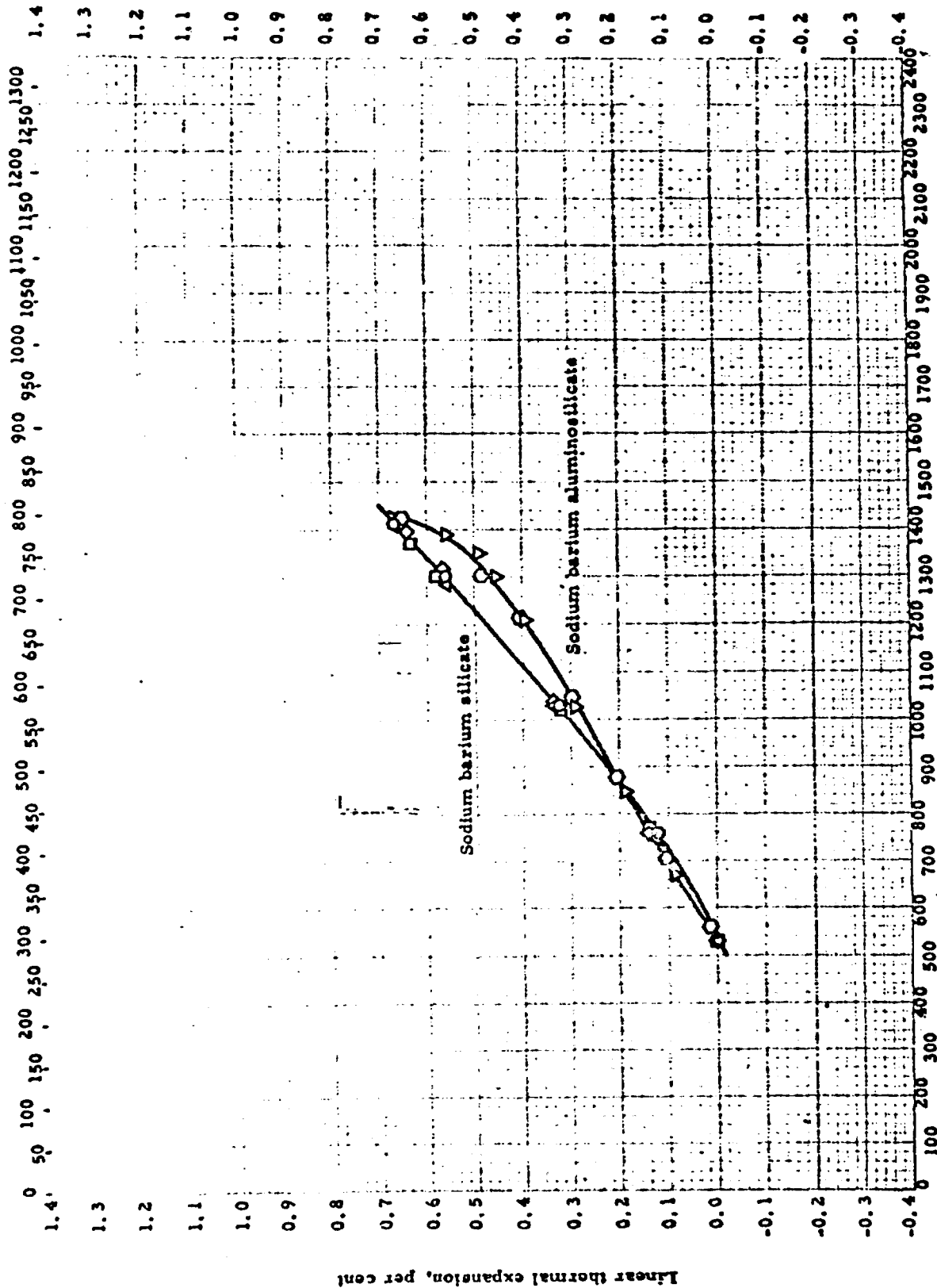
EMISSIVITY -- SODA LIME GLASS

EMISSIVITY -- SODA LIME GLASS
(L.O.F.)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Olsen, O. M. and Morris, J. C.	59-1	150-1360	Glass - soda lime, L.O.F.	Total normal emissivity: comparative; surface brightness compared with that of a black body hole; quartz lens thermocouple, accuracy $\pm 3\%$	1/2 in. sample in air
0	Ed14.	59-1	150-1360	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity from black body at sample temp.	Same as above. Reflectivity \approx 1-emissivity-transmissivity

Temperature, °K



Temperature, °R

LINEAR THERMAL EXPANSION -- SODIUM BARIUM SILICATE GLASS.

LINEAR THERMAL EXPANSION -- SODIUM BARIUM SILICATE GLASS

REFERENCE INFORMATION

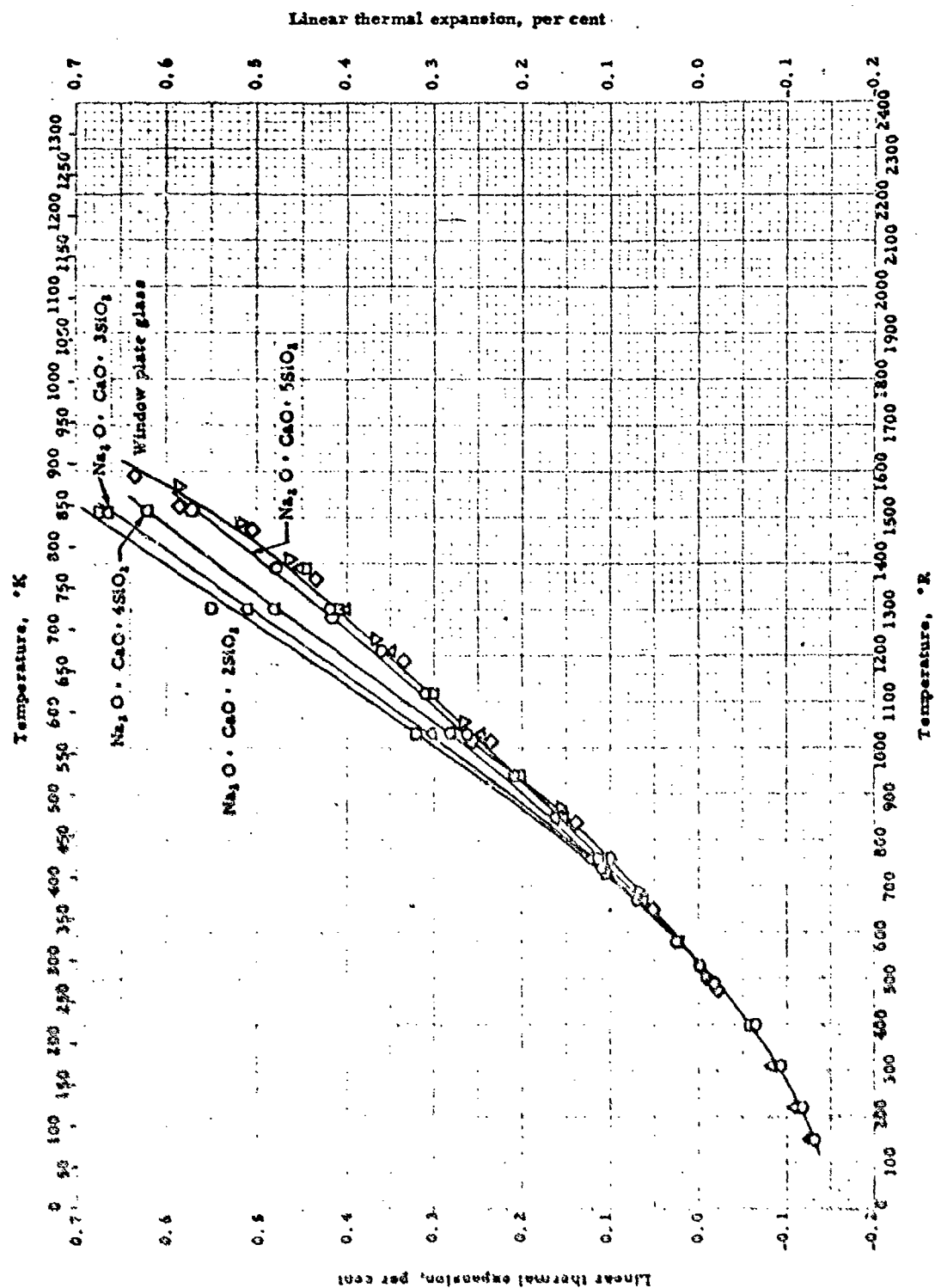
Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
52-32	Karhanavala, M. D. and Hummel, F. A.	528-1410	58.25% SiO ₂ ; 29.74% BaO; 12.02% Na ₂ O	Interferometer and vitreous silica dilatometry	Na ₂ O · BaO · 5SiO ₂ mixed, melted in kyanite crucible, cast in graphite mold, annealed
54-32	Idid.	528-1370	53.75% SiO ₂ ; 33.65% BaO; 13.6% Na ₂ O	Same as above	Na ₂ O · BaO · 4SiO ₂ Formed as above
52-32	Idid.	528-1406	45.86% SiO ₂ ; 38.76% BaO; 15.66% Na ₂ O	Same as above	Na ₂ O · BaO · 3SiO ₂ Formed as above
52-32	Idid.	528-1399	45.71% SiO ₂ ; 38.81% BaO; 15.48% Na ₂ O	Same as above	Na ₂ O · BaO · 2SiO ₂ Formed as above
57-134	Hagt, H. E. and Richard, R. M.	528-1392	Sodium barium aluminosilicate glass, 71.3% SiO ₂ ; 17.4% Na ₂ O; 9.6% BaO; 2.0% Al ₂ O ₃	Quartz differential dilatometer, dial gauges	Refractive index = 1.508 at room temp. 100°C/hr. heating rate. Heating data
57-134	Idid.	537-1428	Same as above	Telemicroscopes sighting on sample	Same as above. Cooling data

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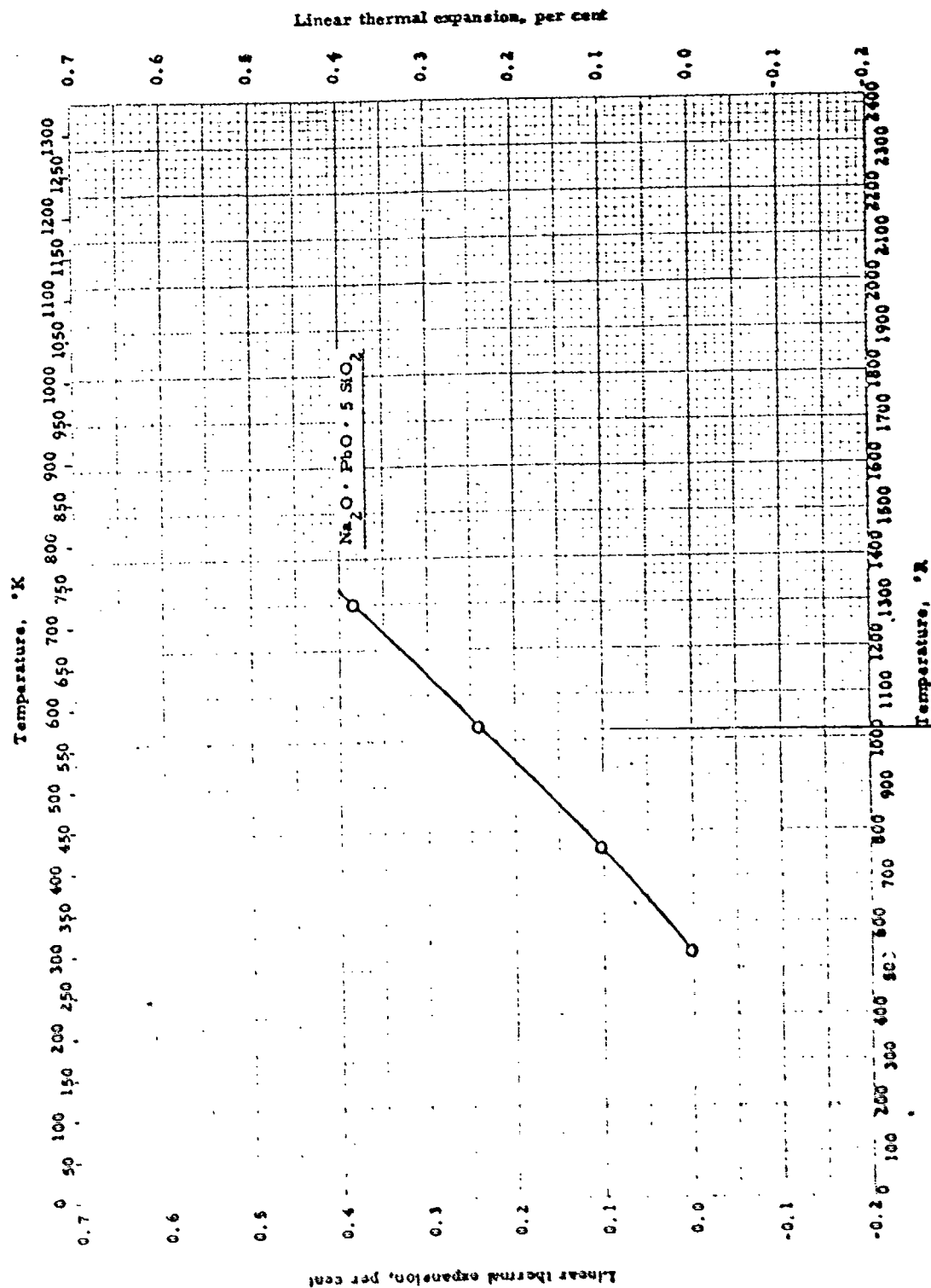


LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Form Col	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Locke, C. F. and Bing, G. F.	52-33	150-1392	Solex 2808X Plate Glass by Pitts- burgh Plate Glass Co.	Dilatometer	
□	Ibid.	52-33	150-1392	Solex "S" Plate Glass by Pittsburgh Plate Glass Co.	Same as above	
△	Ibid.	52-33	150-1392	White (clear) Plate Glass by Pitts- burgh Plate Glass Co.	Same as above	
◇	Hamilton, E. H., Watier, R. and Nivert, J. H.	57-182	492-1590	Ordinary plate glass	Interferometer, with 2° C/min rise	
▽	Ibid.	57-182	492-1572	Water white plate glass	Same as above	
○	Karkhanavala, M. D. and Hummel, F. A.	52-32	528-1536	71.78% SiO ₂ ; 14.82% Na ₂ O; 13.40% CaO	Interferometer and viscous silica dilata- tometer	Na ₂ O · CaO · 5SiO ₂ mixed, melted in kyanite crucible, cast in graphite mold, annealed
○	Ibid.	52-82	528-1518	67.05% SiO ₂ ; 17.30% Na ₂ O; 15.65% CaO	Same as above	Na ₂ O · CaO · 4SiO ₂ formed as above
○	Ibid.	52-82	528-1510	60.42% SiO ₂ ; 20.78% Na ₂ O; 18.80% CaO	Same as above	Na ₂ O · CaO · 3 SiO ₂ formed as above
○	Ibid.	52-82	528-1500	50.44% SiO ₂ ; 26.02% Na ₂ O; 23.44%	Same as above	Na ₂ O · CaO · 2SiO ₂ formed as above

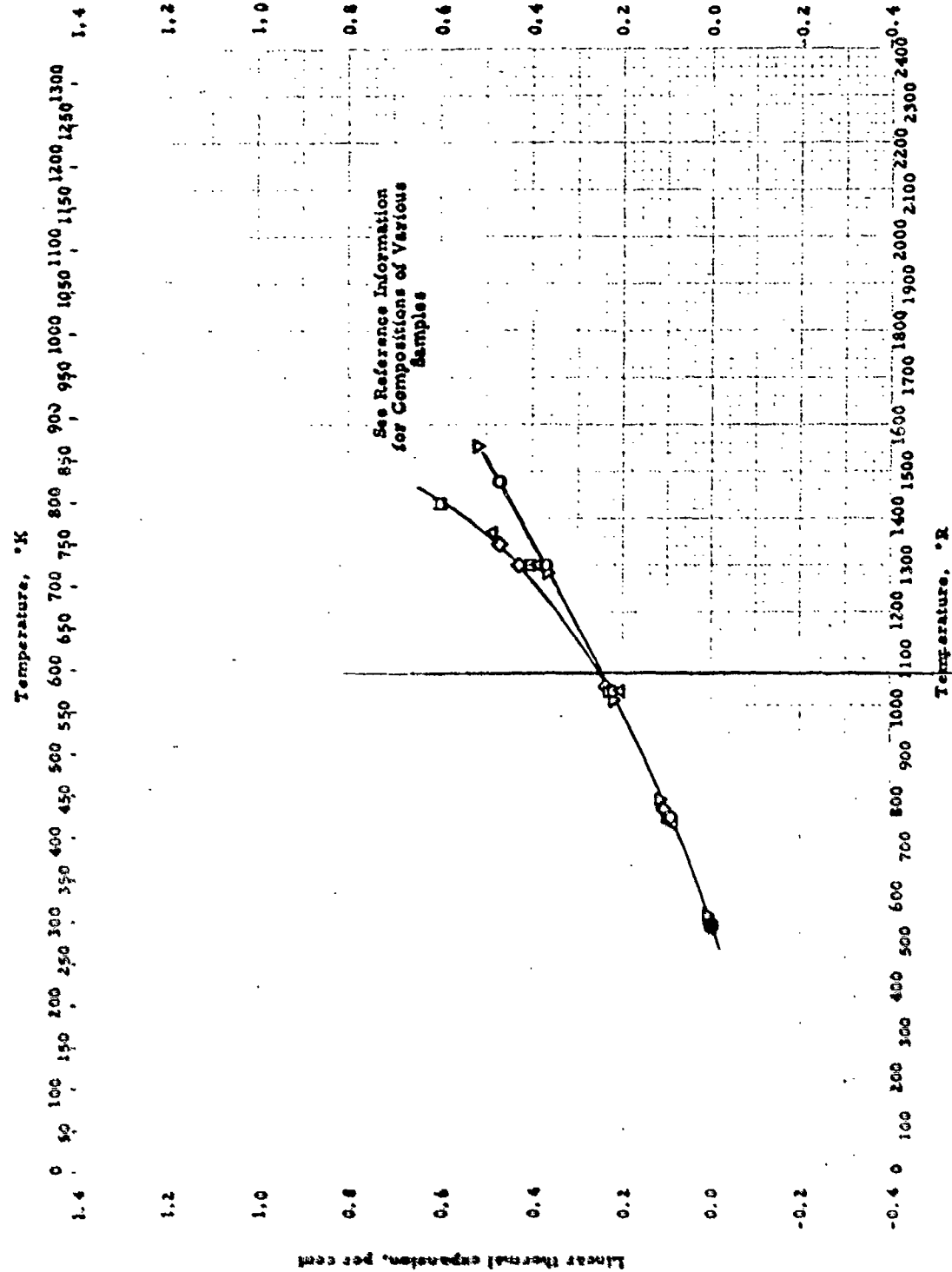


LINEAR THERMAL EXPANSION -- SODIUM LEAD SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

System Code	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Karshavala, M. D., and Hummel, F. A.	52-32	528-1102	51.4% SiO ₂ ; 38.0% PbO; 10.6% Na ₂ O	Interferometer and viscous silica dilatometer	Na ₂ O-PbO-5SiO ₂ mixed, melted in kyanite crucible cast in graphite mold, annealed, tested at 4° C/min rise. Auth. est. accuracy ± 2%

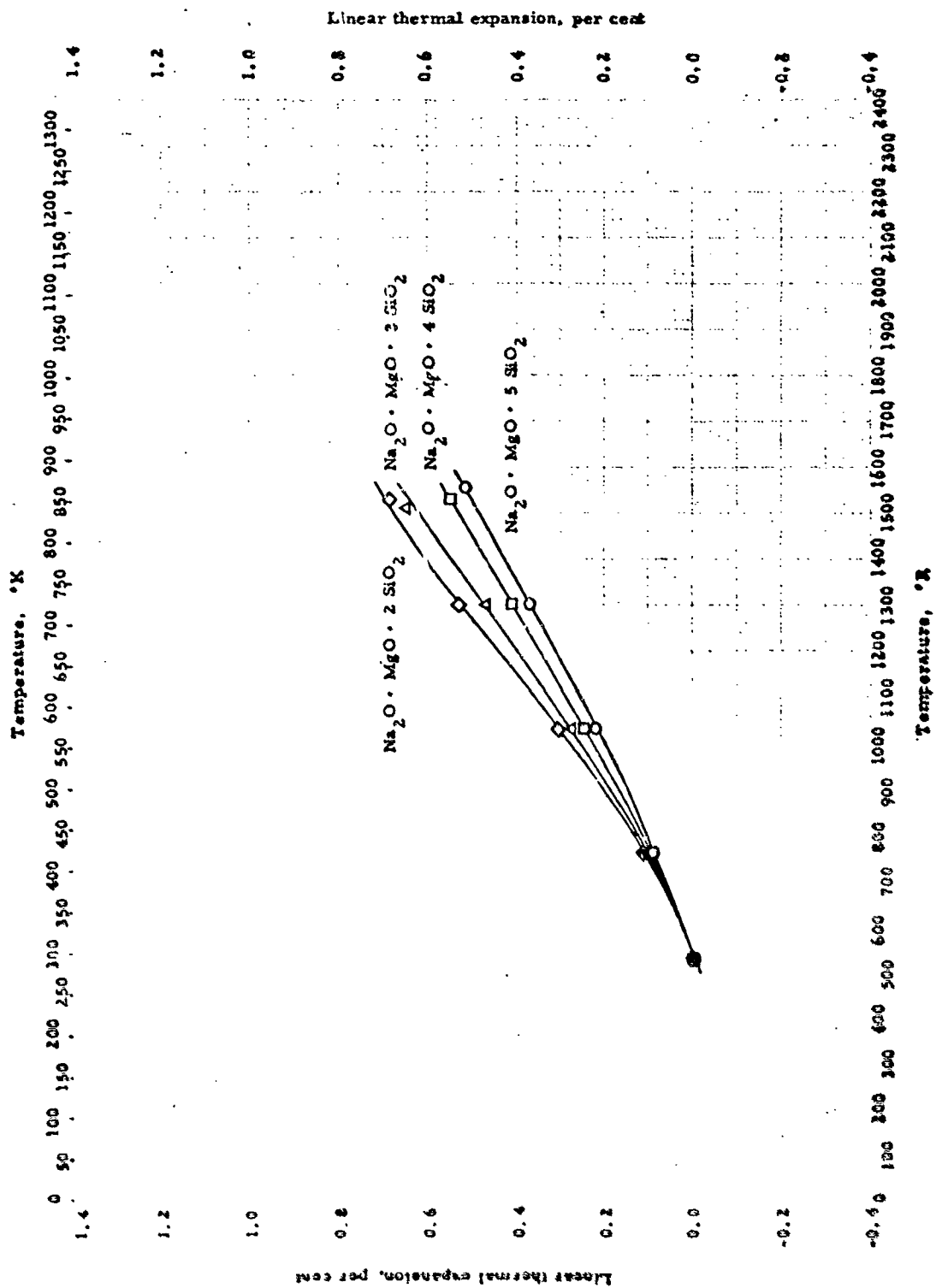


LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM COPPER SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM COPPER SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
▽	Karkhacavala, M. D. and Hummel, F. A.	52-32	528-1555	74.6% SiO ₂ ; 15.4% Na ₂ O; 10.0% MgO	Interferometer and vitreous silica dilatometer	Na ₂ O · MgO · 5 SiO ₂ mixed, melted in kyanite crucibles, cast in graphite mold, annealed; tested at 4°C/min. rise. Auth. est. accuracy ± 2%
○	Ibid.	52-32	528-1482	72.6% SiO ₂ ; 15.0% Na ₂ O; 7.4% MgO; 4.8% CuO	Same as above	Na ₂ O · 0.75 MgO · 0.25 CuO · 5 SiO ₂ ; other remarks as above
□	Ibid.	52-32	528-1428	71.1% SiO ₂ ; 14.7% Na ₂ O; 9.4% CuO; 4.8% MgO	Same as above	Na ₂ O · 0.5 MgO · 0.5 CuO · 5 SiO ₂ ; other remarks as above
△	Ibid.	52-32	528-1374	69.66% SiO ₂ ; 14.40 Na ₂ O; 13.56% CuO; 2.34% MgO	Same as above	Na ₂ O · 0.25 MgO · 0.75 CuO · 5 SiO ₂ ; other remarks as above
◇	Ibid.	52-32	528-1345	66.94% SiO ₂ ; 13.0% CuO; 14.1% Na ₂ O	Same as above	Na ₂ O · CuO · 5 SiO ₂ ; other remarks as above



LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
52-32	Karkhanavala, M. D. and Harkness, F. A.	525-1555	74.6% SiO ₂ ; 15.4% Na ₂ O; 10.0% MgO	Interferometer and vitreous silica dilatometer	Na ₂ O · MgO · 5 SiO ₂ mixed, melted in kyanite crucibles, cast in graphite mold, annealed. Tested at 4° C/min rise. Auth. est. accuracy ± 2%
52-32	Did.	525-1527	70.1% SiO ₂ ; 18.1% Na ₂ O; 11.8% MgO	Same as above	Na ₂ O · MgO · 4 SiO ₂ other remarks as above
52-32	Did.	525-1509	61.8% SiO ₂ ; 21.4% Na ₂ O; 14.3% MgO	Same as above	Na ₂ O · MgO · 3 SiO ₂ other remarks as above
52-32	Did.	525-1527	54.0% SiO ₂ ; 27.9% Na ₂ O; 18.1% MgO	Same as above	Na ₂ O · MgO · 2 SiO ₂ other remarks as above

Symbol	Material Composition, %					Density γ 'cm ³	Coefficient of linear expansion $\times 10^6$ at	
	SiO ₂	N ₂ O	SrO	Al ₂ O ₃	SO ₃		room temperature per °R	per °K
O	77.7	13.9	6.1	2.1	0.1	2.4488	47.0	84.6
	77.7	13.8	8.2	0.2	0.1	2.4754	47.9	86.3
	76.1	15.8	6.1	2.0	0.2	2.4673	50.5	90.9
	76.0	15.4	8.1	0.2	0.2	2.4955	51.8	93.2
	75.4	14.2	6.1	4.0	0.1	2.4643	45.6	82.0
	74.8	17.2	4.0	4.0	0.2	2.4520	51.3	92.4
	74.7	17.1	6.0	2.0	0.2	2.4798	53.7	96.6
	74.3	15.5	6.1	4.1	0.2	2.4776	50.2	90.4
	74.1	17.3	7.9	0.3	0.2	2.5110	55.9	100.6
	73.5	14.1	10.0	2.0	0.2	2.5257	49.1	88.3
	73.5	13.9	12.0	0.3	0.1	2.5571	50.4	90.8
	72.2	15.5	10.1	2.1	0.1	2.5456	53.1	95.5
	71.9	15.7	12.2	0.1	0.1	2.5777	54.6	98.2
	71.5	14.2	10.0	4.1	0.2	2.5380	48.2	86.7
	70.7	17.0	11.9	0.1	0.2	2.5866	58.4	105.2
	70.6	17.2	8.0	4.0	0.2	2.5357	54.2	97.5
	70.5	17.3	10.1	2.0	0.2	2.5569	56.4	101.5
	70.1	15.5	13.1	4.1	0.1	2.5543	52.7	94.9
	69.6	14.1	13.9	2.0	0.2	2.6085	52.5	94.5
	69.5	14.0	16.0	0.2	0.2	2.6392	50.4	95.1
	68.0	15.8	16.0	0.1	0.2	2.6585	57.9	104.2
	68.0	15.7	14.0	2.0	0.2	2.6247	56.7	102.0
	67.9	14.2	13.9	4.1	0.2	2.6165	51.3	92.4
	66.6	17.3	15.6	0.2	0.2	2.6686	61.8	111.2
	66.6	17.3	13.6	2.1	0.2	2.6362	59.6	107.2
	66.8	17.2	11.7	4.0	0.2	2.6059	58.2	104.8
	66.1	15.5	14.0	4.1	0.2	2.6329	56.6	101.9

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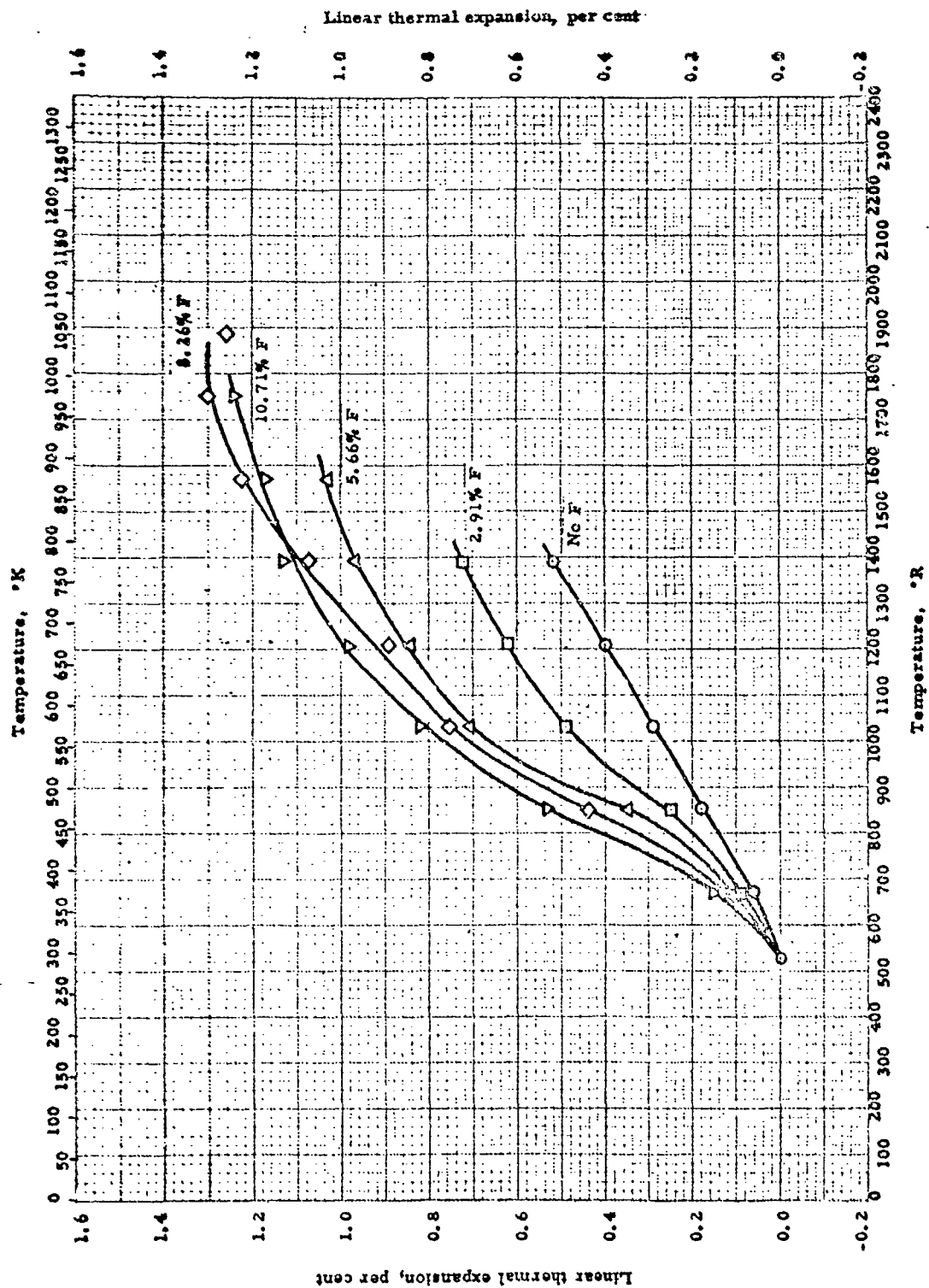
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LINEAR THERMAL EXPANSION -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Specimen	Investigator	Rad.	Range, °R	Material Composition	Test Method	Remarks
0	Owens Illinois Glass Co. Research Labs	48-38	Room	Series of glasses	Not given here; refers to earlier work	



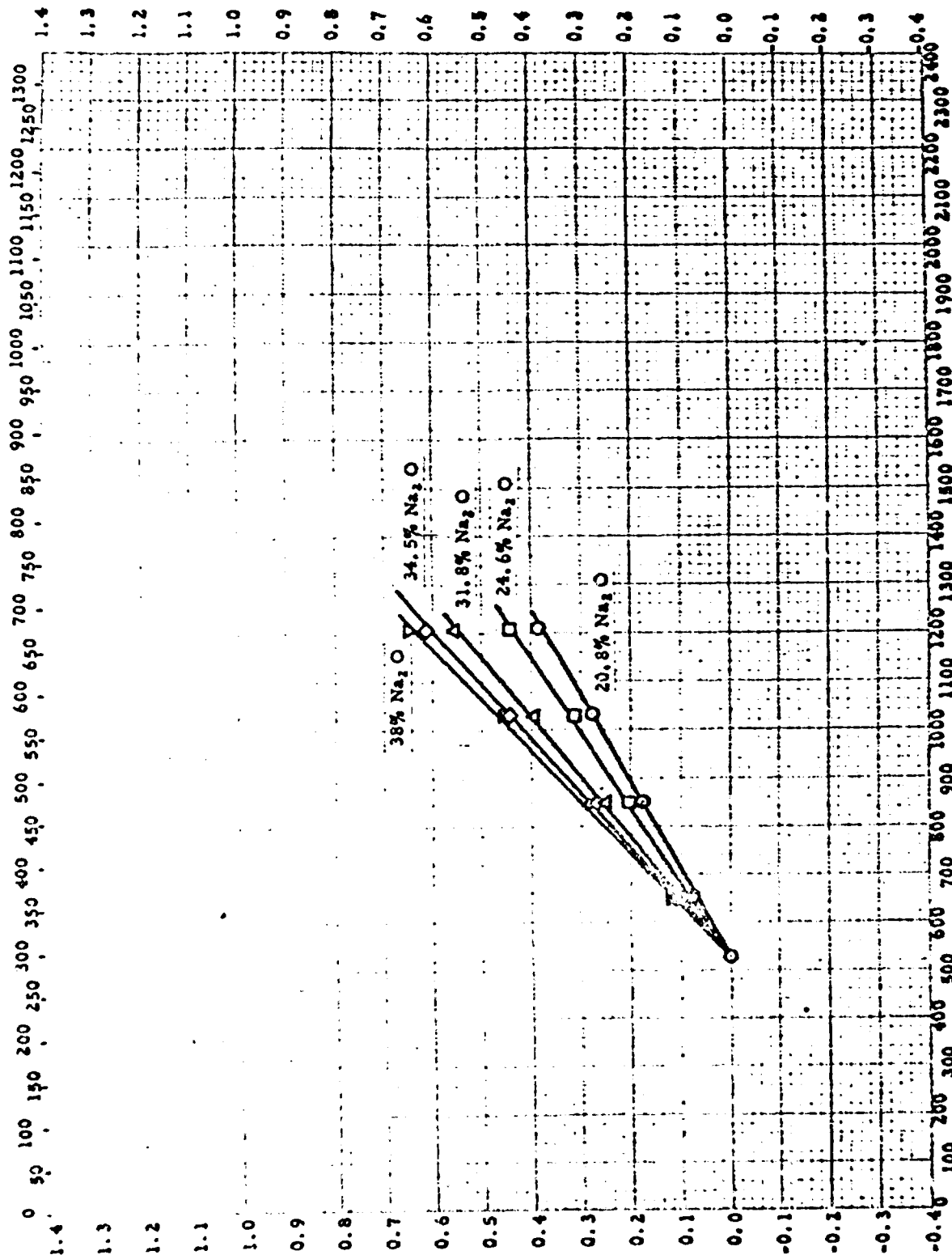
LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS WITH FLUORINE

LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS WITH FLUORINE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vargin, V. V. and Krasotkina, N. L.	56-168	672-1392	74.41% SiO ₂ ; 25.59% Na ₂ O	Quartz tube dilatometer with dial gauge	Pure materials heated to 780°C in muffle furnace, furnace cooled. Auth. est. accuracy ± 1.5%
□	Ibid.	56-168	672-1392	72.24% SiO ₂ ; 24.85% Na ₂ O; 2.91% F	Same as above	Same as above
△	Ibid.	56-168	672-1572	70.20% SiO ₂ ; 24.14% Na ₂ O; 5.66% F	Same as above	Same as above
◇	Ibid.	56-168	672-1642	68.27% SiO ₂ ; 23.47% Na ₂ O; 8.26% F	Same as above	Same as above
▽	Ibid.	56-168	672-1752	66.44% SiO ₂ ; 22.85% Na ₂ O; 10.71% F	Same as above	Same as above. Auth. also report values for various heat treatments in the system 66-75% SiO ₂ + 22-26% Na ₂ O + 0-10% F

Temperature, °K



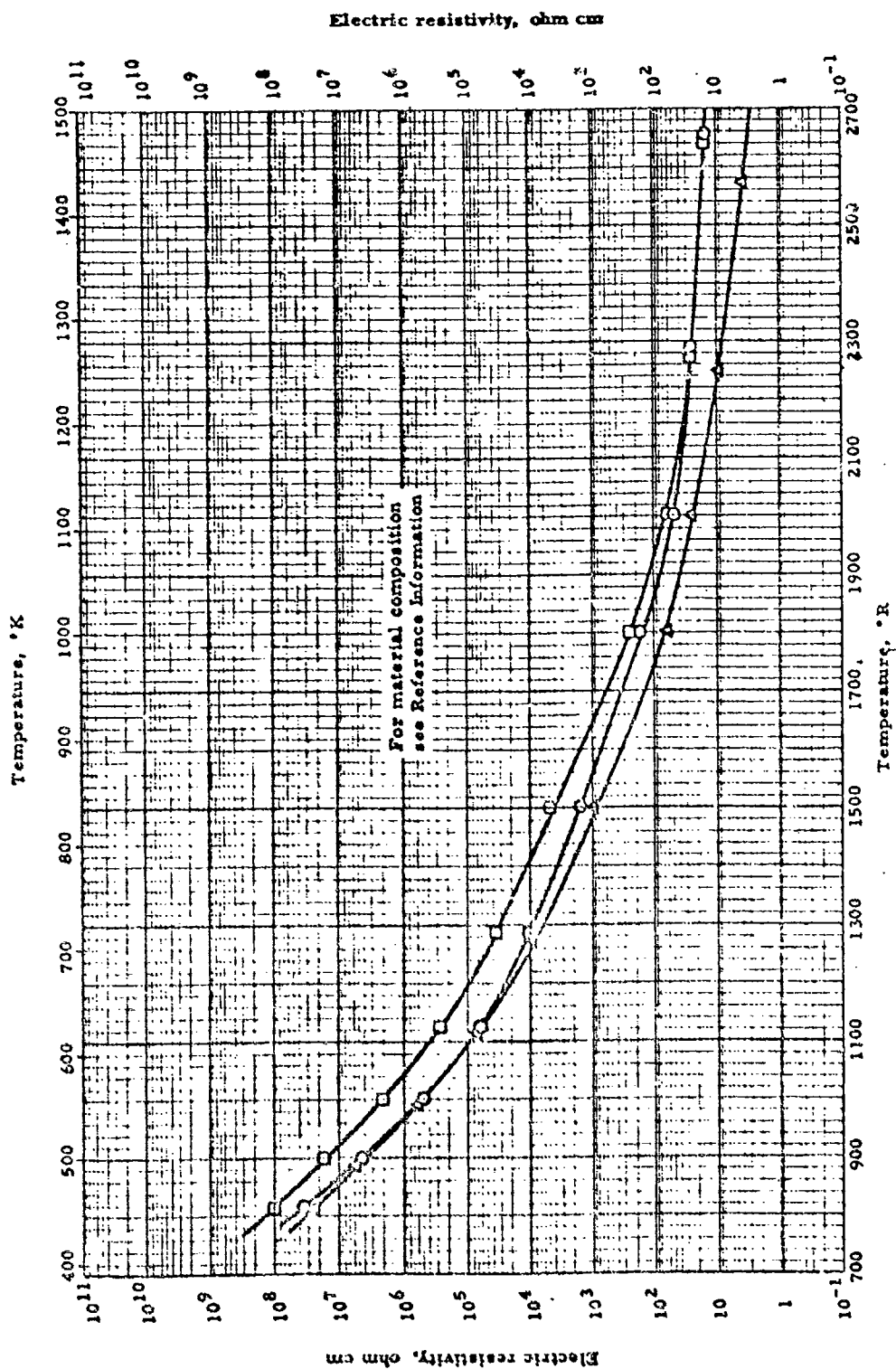
Temperature, °K

LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-166	528-1212	79.2% SiO ₂ ; 20.8% Na ₂ O, $\rho = 148.8 \text{ lb}_m/\text{ft}^3$	Interferometer	
□	Ibid.	56-166	528-1212	75.4% SiO ₂ ; 24.6% Na ₂ O, $\rho = 151.1 \text{ lb}_m/\text{ft}^3$	Same as above	
△	Ibid.	56-166	528-1212	68.2% SiO ₂ ; 31.8% Na ₂ O, $\rho = 154.3 \text{ lb}_m/\text{ft}^3$	Same as above	
◇	Ibid.	56-166	528-1212	65.5% SiO ₂ ; 34.5% Na ₂ O, $\rho = 155.5 \text{ lb}_m/\text{ft}^3$	Same as above	
▽	Ibid.	56-166	528-1212	62.0% SiO ₂ ; 38.0% Na ₂ O, $\rho = 156.5 \text{ lb}_m/\text{ft}^3$	Same as above	

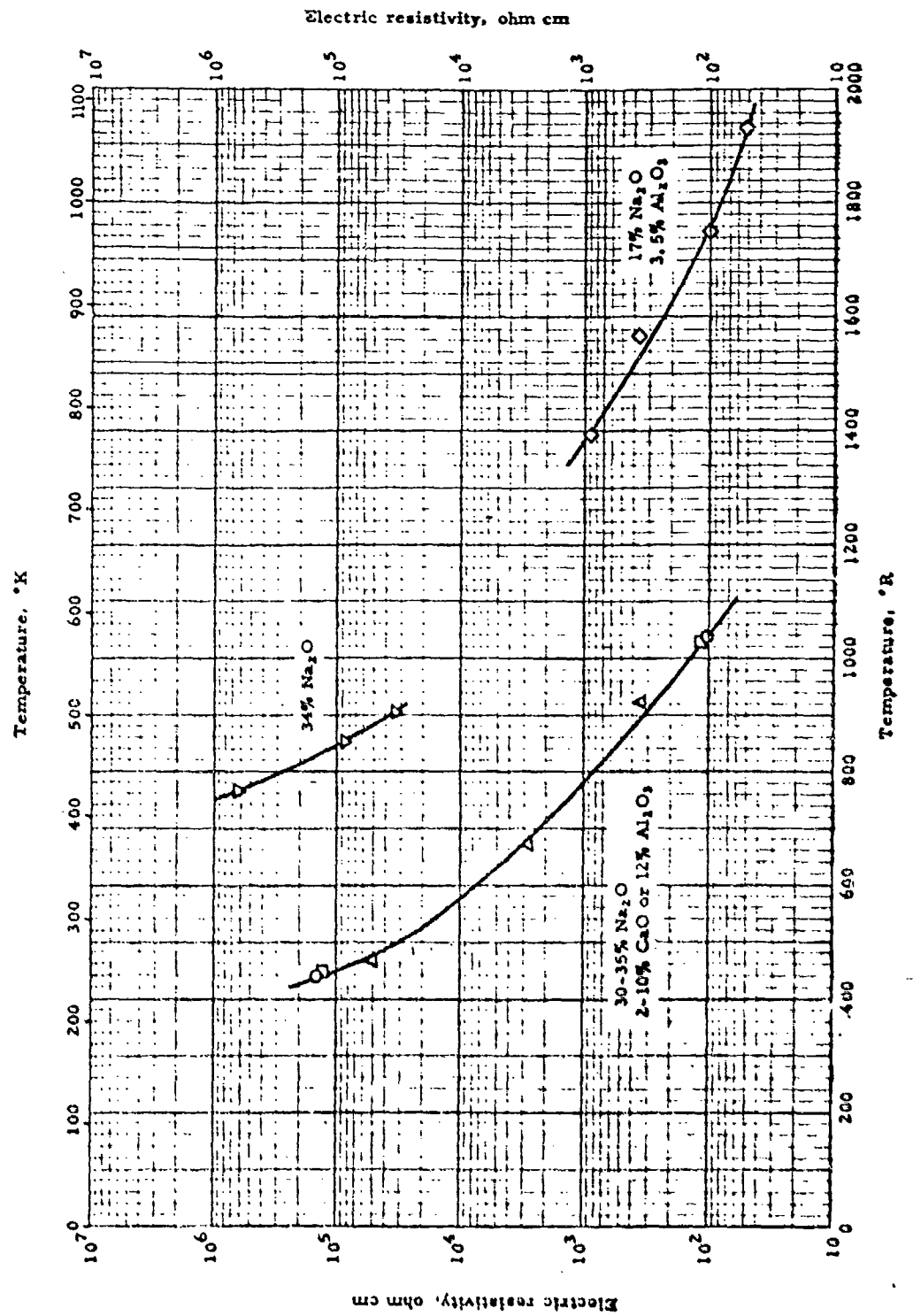


ELECTRIC RESISTIVITY -- SODA LIME ALUMINOSILICATE GLASS

ELECTRIC RESISTIVITY -- SODA LIME ALUMINOSILICATE CLASS

REFERENCE INFORMATION

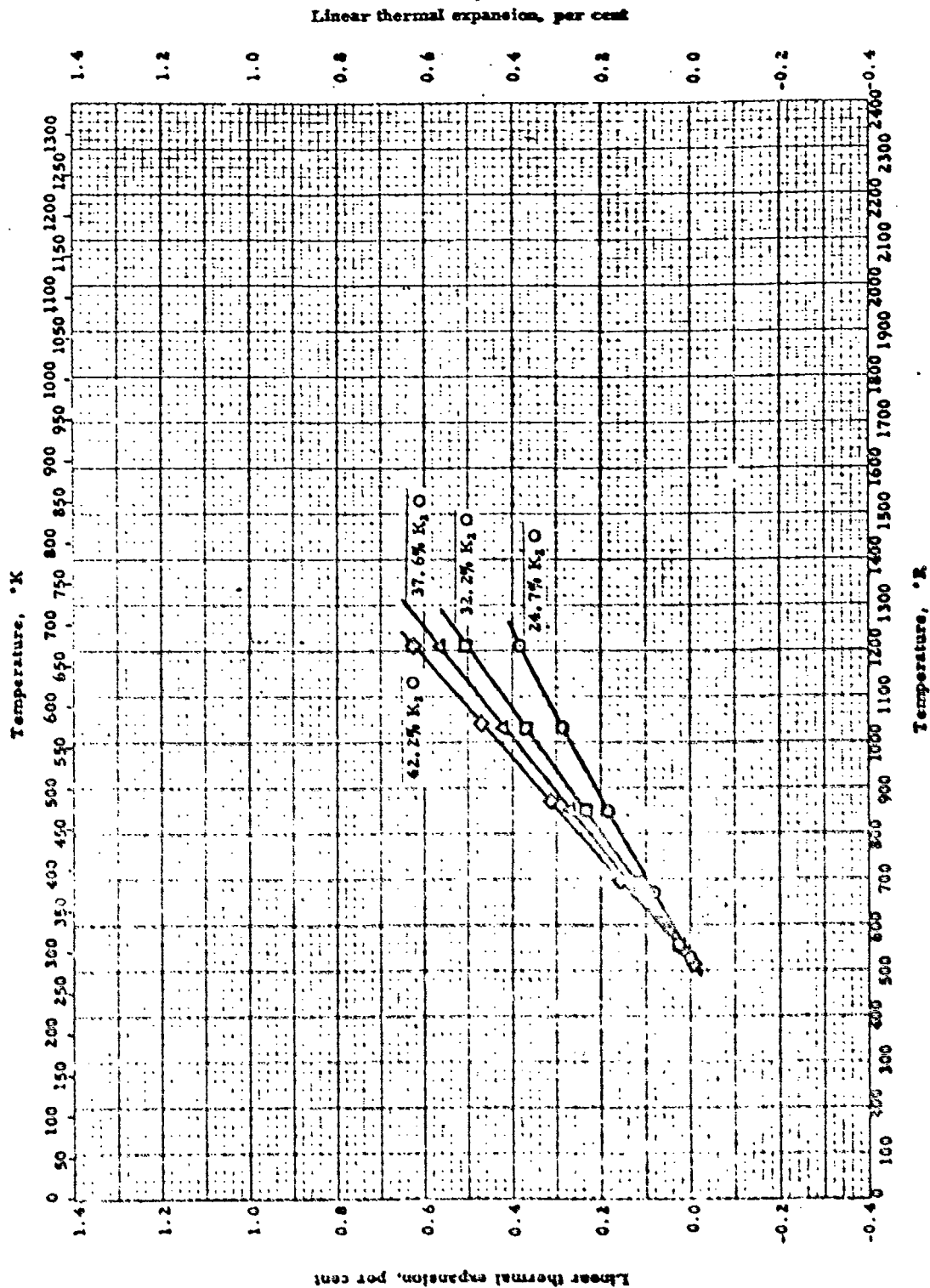
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kostanyan, K. A.	57-188	818-2652	75.77% SiO ₂ ; 12.43% Na ₂ O; 7.36% CaO; 4.33% Al ₂ O ₃ ; 0.25% MgO, before melting	Two methods: a. $10^7 < r < 10^{10}$ ohm lamp gage ohmmeter b. $r < 10^7$ ohms AC impedance bridge at 50 cycles	Melted from chemically pure materials in fire clay single liter crucibles in petroleum furnace
□	Ibid.	57-188	818-2571	74.0% SiO ₂ ; 13.0% Na ₂ O; 11.0% CaO; 2.0% Al ₂ O ₃ , before melting	Same as above	Same as above
△	Ibid.	57-188	818-2571	72.0% SiO ₂ ; 17.0% Na ₂ O; 7.0% CaO; 2.0% ca. Al ₂ O ₃ , MgO, before melting	Same as above	Same as above. Auth. reports additional detailed data for system, 72-76% SiO ₂ ; 12.4-17% Na ₂ O; 7-10% CaO; 2-4.3% Al ₂ O ₃ ; 0.2% MgO. Only extreme ranges of resistivity are shown here.



ELECTRIC RESISTIVITY -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Joyner, B. L. and Bell, W. C.	53-105	440-1040	60% SiO ₂ ; 30% Na ₂ O; 10% CaO	Two methods: a: $r < 10^5$ ohms: Wheatstone bridge b: $r > 10^5$ ohms: megohmmeter	
□	Ibid.	53-105	440-1040	63% SiO ₂ ; 35% Na ₂ O; 2% CaO	Same as above	
△	Ibid.	53-105	464-924	56% SiO ₂ ; 32.5% Na ₂ O; 11.5% Al ₂ O ₃	Same as above	
◇	Leung, K.	46-15	1392-2114	67.8% SiO ₂ ; 17.0% Na ₂ O; 12.0% CaO; 3.2% Al ₂ O ₃	AC impedance bridge at 10 ³ cycles; sample temp. by Pt-Pt Rh thermocouple	
▽	Struss, E. W.	56-163	762-906	66.0% SiO ₂ ; 34.0% Na ₂ O	Potential drop, DC reversal	Made from reagent grade materials

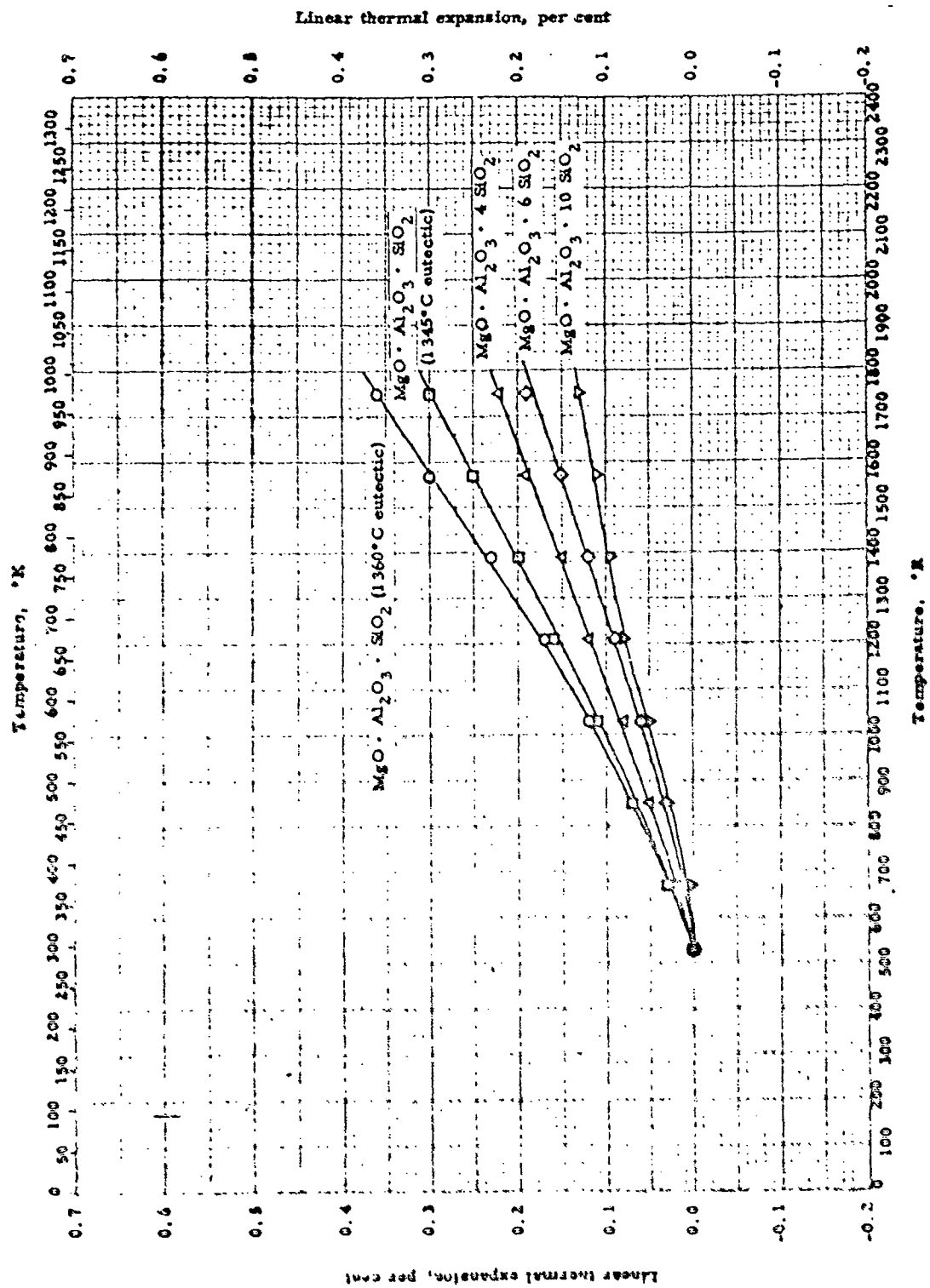


LINEAR THERMAL EXPANSION -- POTASSIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- POTASSIUM SILICATE GLASS

REFERENCE INFORMATION

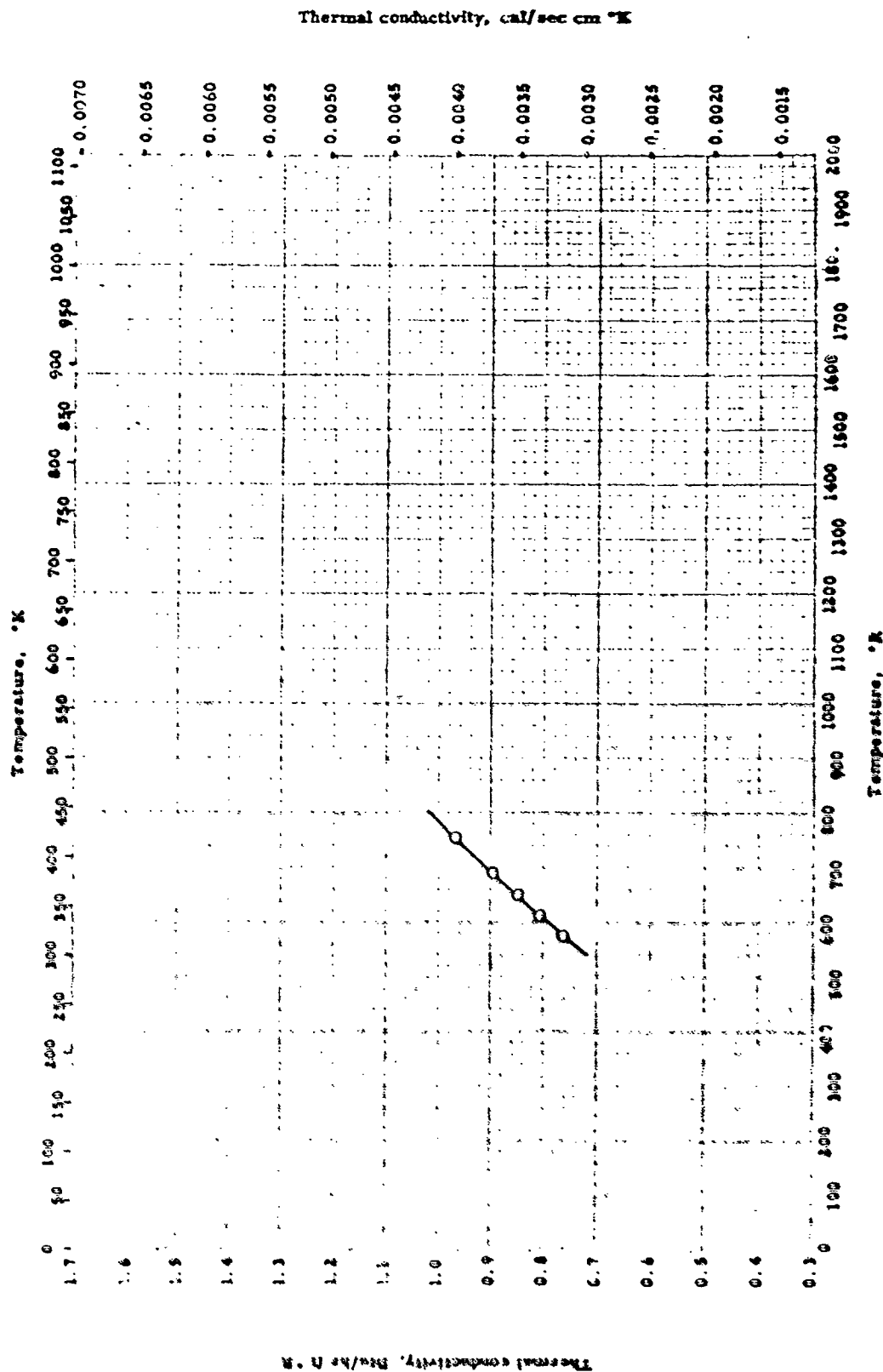
SYN- No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Shermer, H. F.	56-166	523-1212	75.3% SiO ₂ ; 24.7% K ₂ O $\rho = 147.6 \text{ lb/in}^3$	Interferometer	2 specimens, one of which was reannealed
Q	Did.	56-166	523-1212	67.8% SiO ₂ ; 32.2% K ₂ O $\rho = 144.8 \text{ lb/in}^3$	Same as above	Reannealed
Q	Did.	56-166	523-1212	62.4% SiO ₂ ; 37.6% K ₂ O $\rho = 151.9 \text{ lb/in}^3$	Same as above	2 specimens, one of which was reannealed
Q	Did.	56-166	523-1212	57.8% SiO ₂ ; 42.2% K ₂ O $\rho = 153.3 \text{ lb/in}^3$	Same as above	Reannealed



LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINUM SILICATE GLASSES

REFERENCE INFORMATION

Fig.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hammett, F. A., and Ridg, H. W.	51-23	528-1752	94.0% SiO ₂ ; 25.0% MgO; 21.0% Al ₂ O ₃ ; prepared from c.p. MgO, c.p. Al ₂ O ₃ , potter's flint (99.8% SiO ₂)	Interferometer	1360°C eutectic MgO · Al ₂ O ₃ · SiO ₂
□	1314.	51-23	528-1752	61.4% SiO ₂ ; 20.3% MgO; 18.3% Al ₂ O ₃ ; raw materials same as above	Same as above	1345°C eutectic MgO · Al ₂ O ₃ · SiO ₂
△	1314.	51-23	528-1752	62.5% SiO ₂ ; 26.6% Al ₂ O ₃ ; 10.5% MgO; raw materials same as above	Same as above	MgO · Al ₂ O ₃ · 4SiO ₂
◇	1314.	51-23	528-1752	71.7% SiO ₂ ; 20.2% Al ₂ O ₃ ; 8.0% MgO; raw materials same as above	Same as above	MgO · Al ₂ O ₃ · 6SiO ₂
▽	1314.	51-23	528-1752	85.6% SiO ₂ ; 13.7% Al ₂ O ₃ ; 1.4% MgO; raw materials same as above	Same as above	MgO · Al ₂ O ₃ · 10 SiO ₂



Thermal conductivity -- LIME WINDOW GLASS

THERMAL CONDUCTIVITY -- LIME WINDOW GLASS

REFERENCE INFORMATION

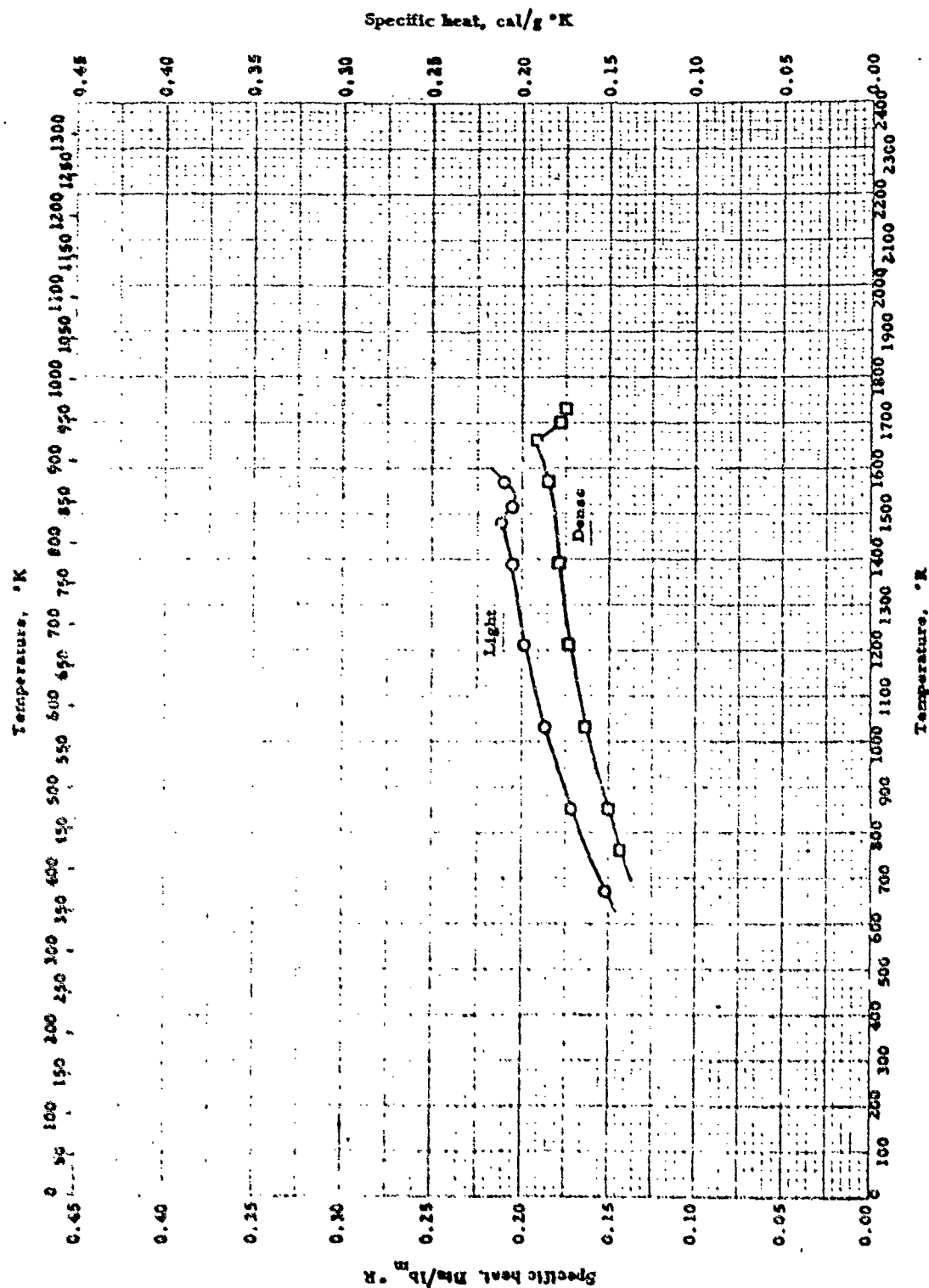
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Koenig, J. H.	53-43	575-760	lime window glass. American Ceramic Society Standard Glass ps 155 lb _m /ft ²	Comparative; rod in vacuum; ibconel standards	Used Pt alloy glaze for ceramic to metal bond

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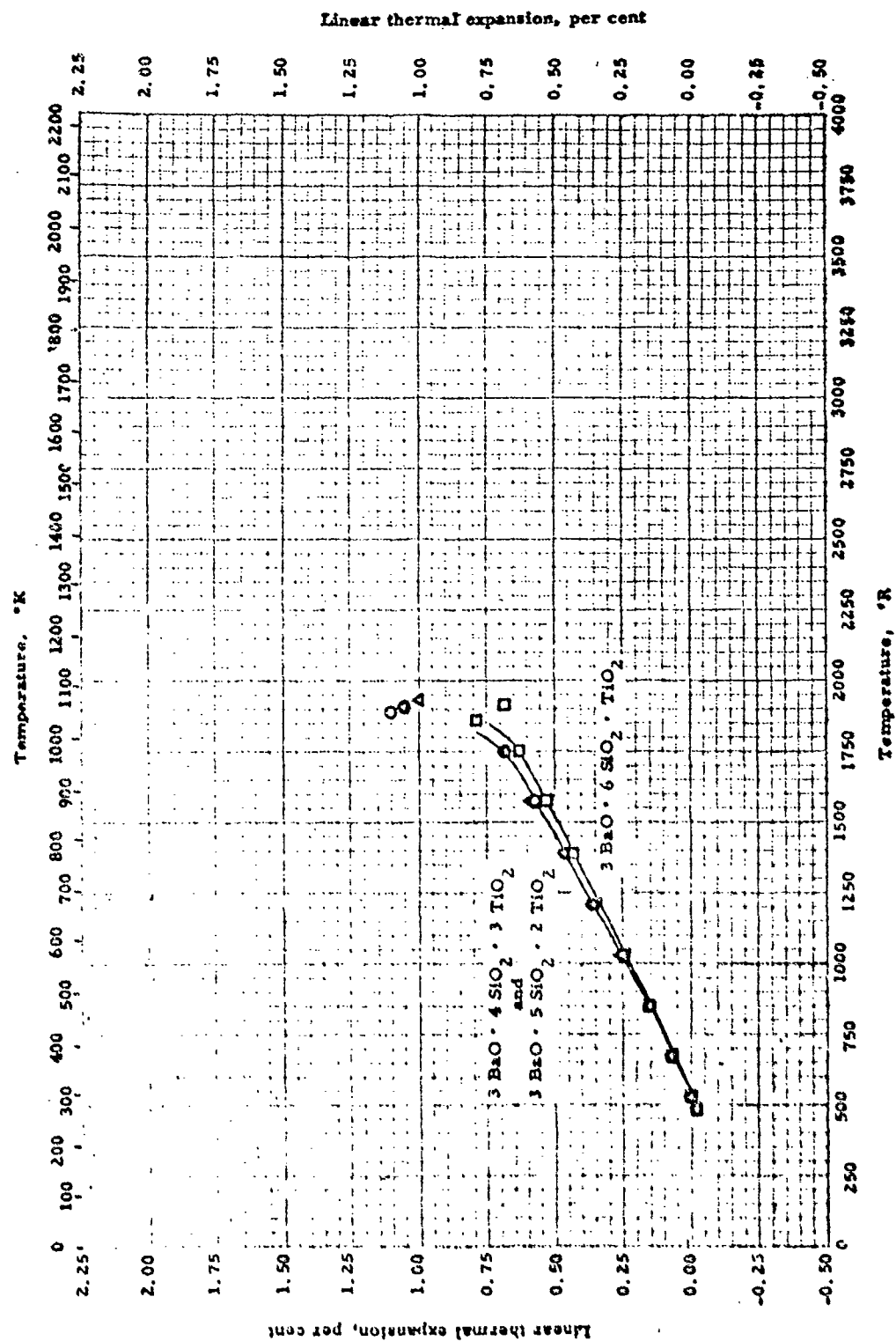


SPECIFIC HEAT -- BARIUM CROWN GLASS

SPECIFIC HEAT -- BARIUM CROWN GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Prod'homme, M.	55-43	672-1572	Light barium crown glass	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	Auth. believes second-order transformation at 550°C
□	Indd.	55-43	762-1734	Dense barium crown glass	Same as above	Auth. believes second-order transformation at 650°C



LINEAR THERMAL EXPANSION -- BARIUM TITANIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- BARIUM TITANIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-20	Cirak, G. W. and Hamilton, E. H.	492-1914	48.9% BaO; 25.6% SiO ₂ ; 25.5% TiO ₂	Interferometer	3 BaO : 4.2 SiO ₂ : 3 TiO ₂
56-20	Ibid.	492-1932	50.0% BaO; 32.6% SiO ₂ ; 17.4% TiO ₂	Same as above	3 BaO : 5 SiO ₂ : 2 TiO ₂
56-20	Ibid.	492-1914	51.1% BaO; 40.0% SiO ₂ ; 8.9% TiO ₂	Same as above	3 BaO : 6.8 SiO ₂ : TiO ₂

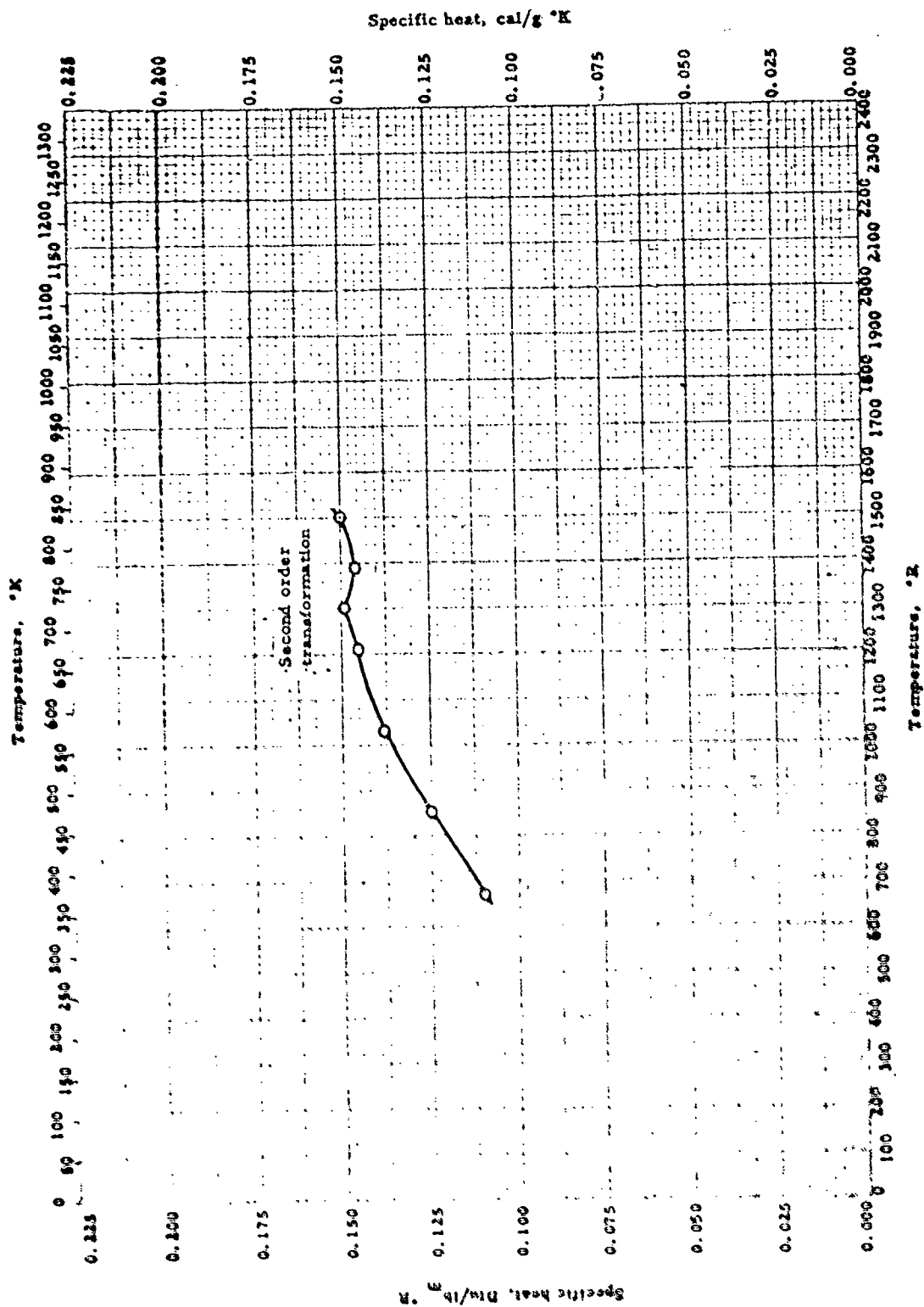
Symbol	Density	
	$\frac{\text{lb}}{\text{m}^3}$	$\frac{\text{g}}{\text{cm}^3}$
○	189.74	3.0394
□	189.64	3.0377
△	190.34	3.0489
◇	190.59	3.0529
▽	191.46	3.0668
○	192.96	3.0909
□	189.64	3.0377
△	190.34	3.0489
◇	190.59	3.0529
▽	191.46	3.0668
△	192.96	3.0909

DENSITY -- LEAD SILICATE GLASS

DENSITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vickery, R. C. and Sedlack, R.	57-197	530-535	"Corning 0120" glass	p: pycnometer with water free of CO ₂ and air bubbles	Ground base glass mixtures were milled, melted, reground, milled, remelted, annealed 4-8 hrs. at 500°C
□	Ibid.	57-197	530-535	"Corning 0120" glass + 0.1% Nd ₂ O ₃	p: same as above	
△	Ibid.	57-197	530-535	"Corning 0120" glass + 0.25% Nd ₂ O ₃	p: same as above	Same as above
○	Ibid.	57-197	530-535	"Corning 0120" glass + 0.5% Nd ₂ O ₃	p: same as above	Same as above
▽	Ibid.	57-197	530-535	"Corning 0120" glass + 1.0% Nd ₂ O ₃	p: same as above	Same as above
○	Ibid.	57-197	530-535	"Corning 0120" glass + 2.0% Nd ₂ O ₃	p: same as above	Same as above; auth. also report additional density data for additives of 0.1-2.0% of other rare earth oxides
○	Vickery, R. C. and Sedlack, R.	57-187	530-535	"Corning 0120" glass + 0.20% Nd ₂ O ₃	p: pycnometer with water free of CO ₂	
○	Ibid.	57-187	530-535	"Corning 0120" glass + 0.53% Nd ₂ O ₃	p: same as above	
○	Ibid.	57-187	530-535	"Corning 0120" glass + 1.29% Nd ₂ O ₃	p: same as above	
○	Ibid.	57-187	530-535	"Corning 0120" glass + 2.50% Nd ₂ O ₃	p: same as above	
△	Ibid.	57-187	530-535	"Corning 0120" glass + 4.96% Nd ₂ O ₃	p: same as above	Auth. also report additional density data for additives of 0.1-2.0% of other rare earth oxides



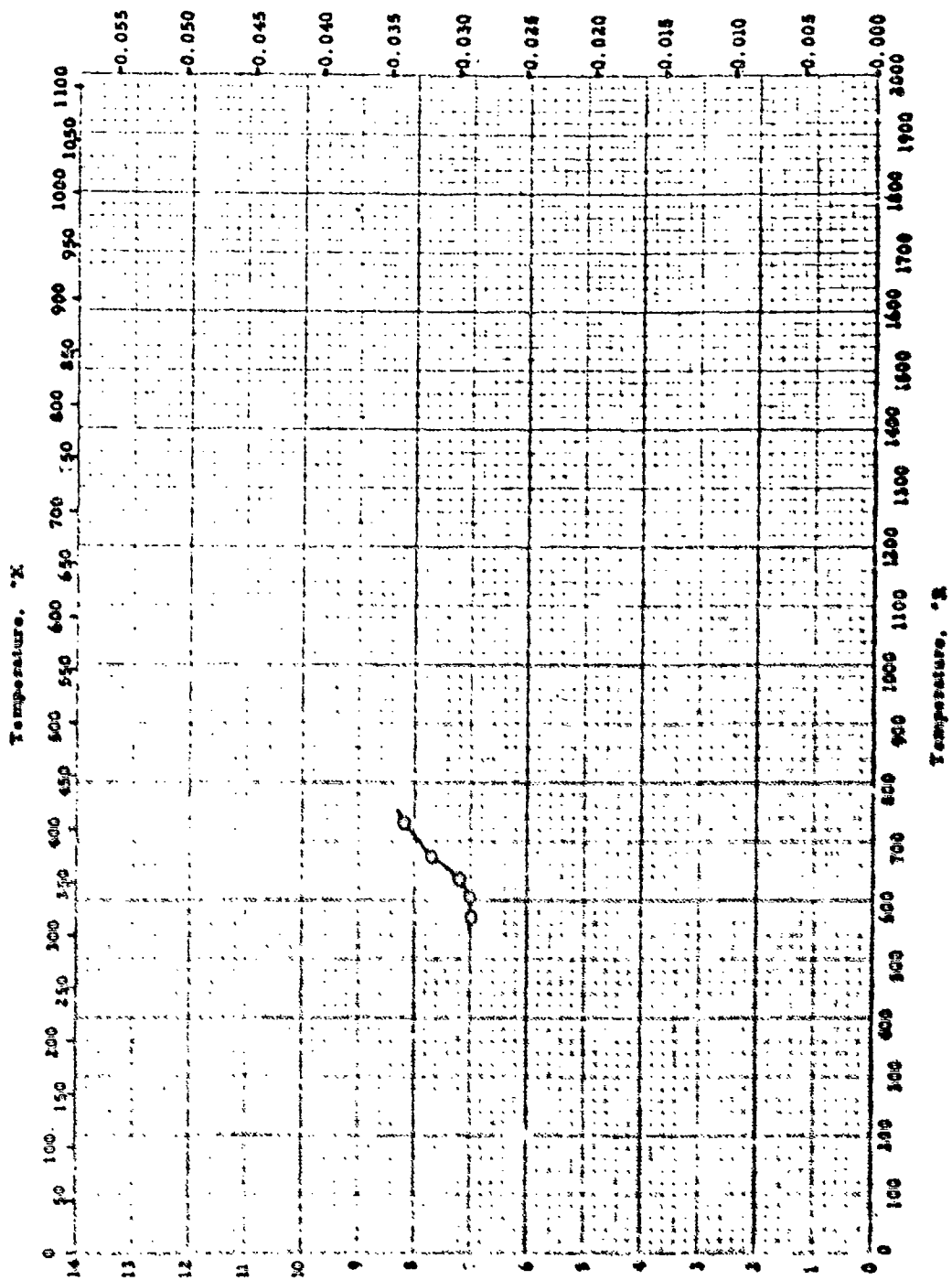
SPECIFIC HEAT -- DENSE FLINT GLASS

SPECIFIC HEAT -- DENSE FLINT GLASS

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
0	Prod'homme, M.	55-43	672-1500	Very dense flint glass	Thermal analysis, silica reference	

Thermal conductivity, cal/sec cm °K



Thermal conductivity -- LEAD SILICATE GLASS

60-725

WADC TR 58-476

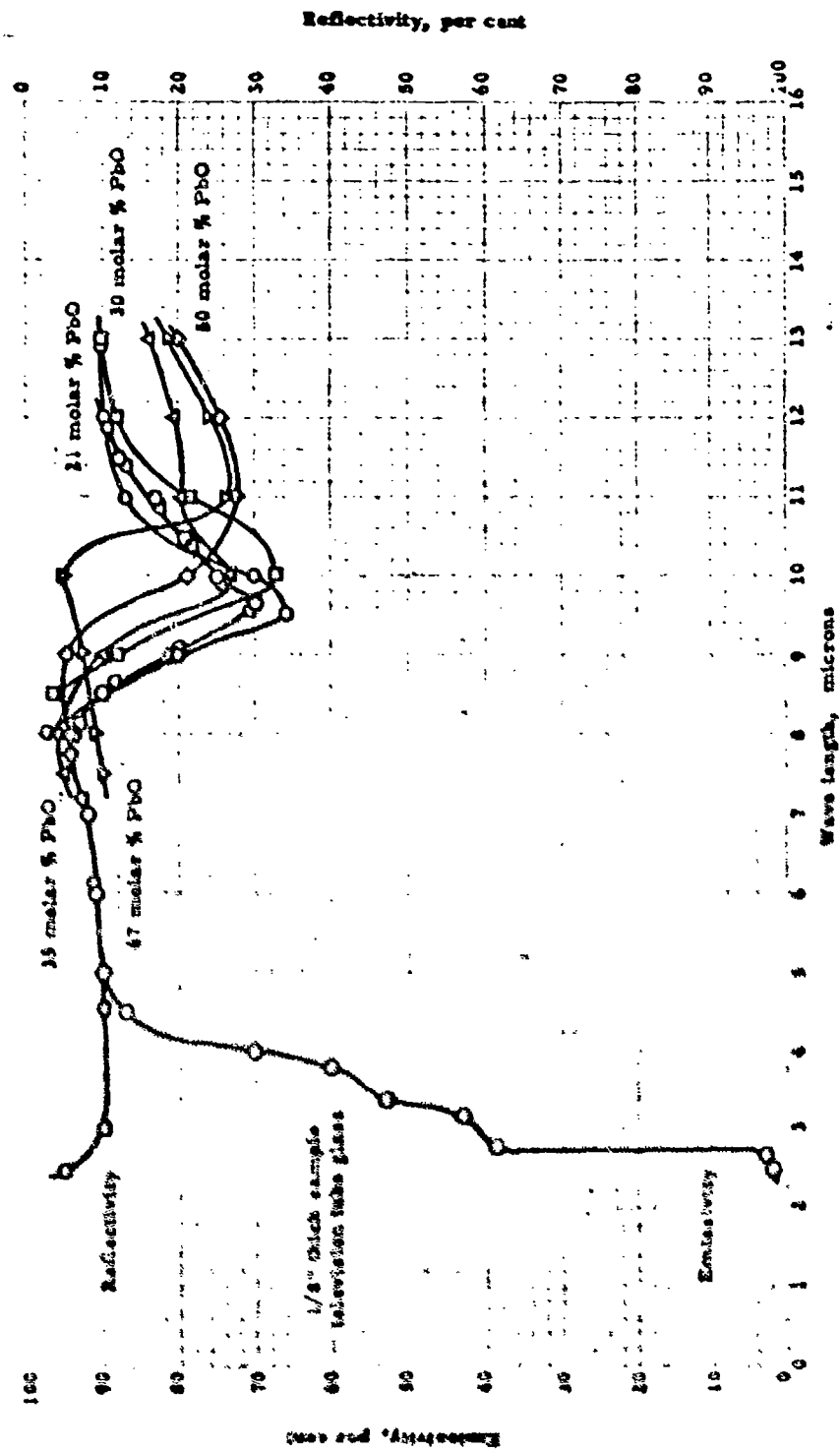
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VI-C-1-1

THERMAL CONDUCTIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koenig, J. H.	53-63	570-740	Lead glass - American Ceramic Soc. standard glass $\rho = 3.04 \text{ g/cm}^3$	Comparative: rods in vacuum; inconel standard	Used Pt alloy glaze for ceramic to metal bond

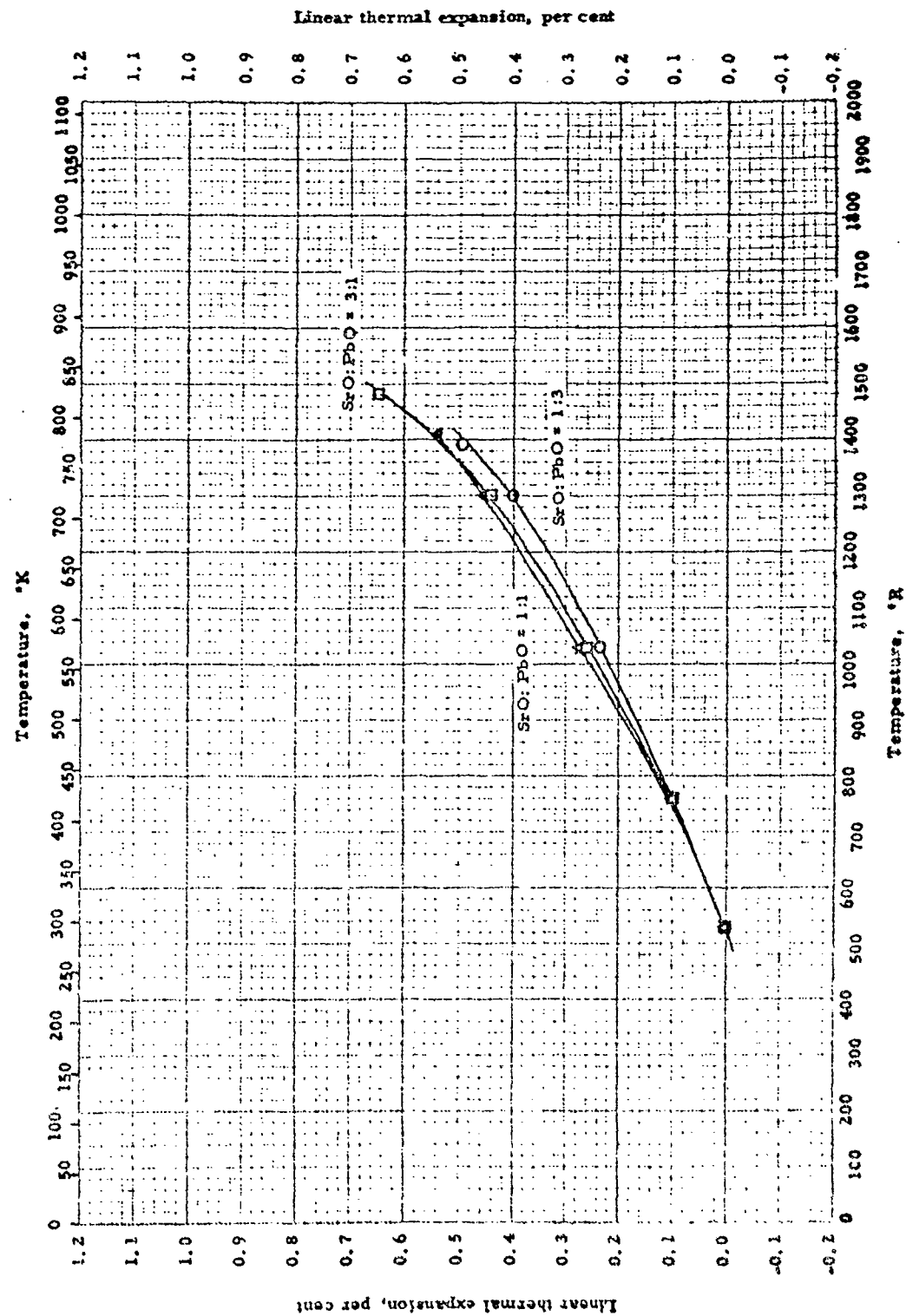


SPECTRAL EMISSIVITY--LEAD SILICATE GLASS

SPECTRAL EMISSIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
1	Floriankaya, V. A.	53-4-66	Room	Average optical film glass, 21 molar% PbO	Spectral reflectivity at 13° compared reflection from sample with aluminum standard mirror by thermopile	Repolished before experiment; author reports fine structure on small scale graphs
2	Did.	53-4-66	Room	Heavy optical film glass, 30 molar% PbO	Same as above	Same as above
3	Did.	53-4-66	Room	Heavy optical film glass, 35 molar% PbO	Same as above	Same as above
4	Did.	53-4-66	Room	Heavy optical film glass, 50 molar% PbO	Same as above	Same as above
5	Did.	53-4-66	Room	Heavy optical film glass, 66.66 molar% PbO	Same as above	Same as above
6	McMahon, H.	53-4-65	1440	Television tube glass containing approx. 30% lead oxide	Spectral emissivity; Perkin-Elmer spectrometer and thermocouple	1/8 in. thick at 1000°F
7	Did.	53-4-65	1440	Same as above	Spectral reflectivity computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1-transmissivity-emissivity



59-296

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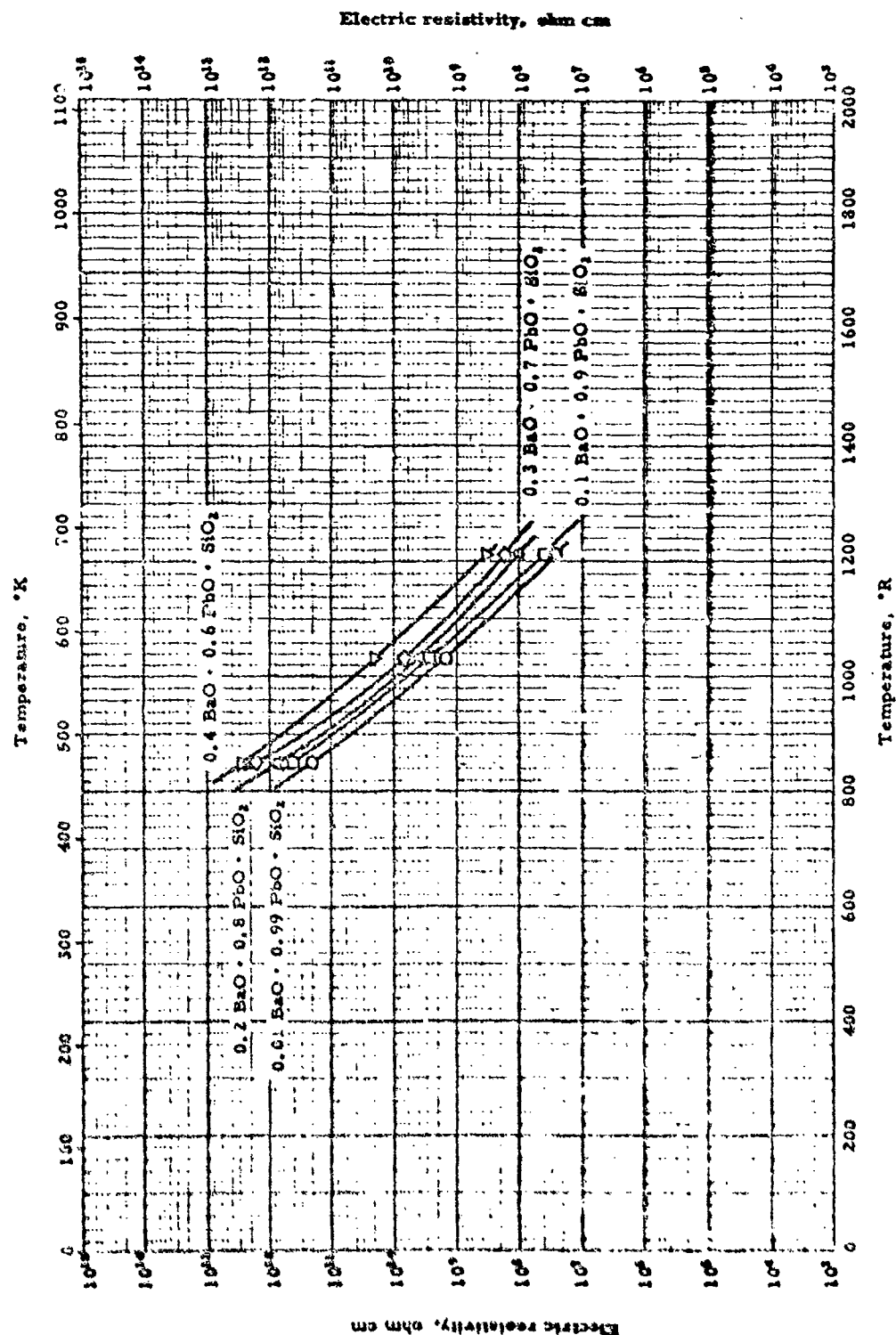
VII - C - 1 -

LINEAR THERMAL EXPANSION -- LEAD STRONTIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LEAD STRONTIUM SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
52-32	Karhanavala, M. D. and Hummel, F. A.	52-32	528-1390	54.1% SiO ₂ ; 30% PbO; 11.2% Na ₂ O; 4.7% SrO	Interferometer and vitreous silica dilatometer	Cast, annealed. Na ₂ O · 0.255 SrO · 0.75 PbO · 5 SiO ₂
52-32	Ibid.	52-32	528-1410	57.2% SiO ₂ ; 21.2% PbO; 11.8% Na ₂ O; 9.3% SrO	Same as above	Cast, annealed. Na ₂ O · 0.55 SrO · 0.5 PbO · 5 SiO ₂
52-32	Ibid.	52-32	528-1482	60.5% SiO ₂ ; 15.7% SrO; 12.5% Na ₂ O; 11.3% PbO	Same as above	Cast, annealed. Na ₂ O · 0.78 SrO · 0.25 PbO · 5 SiO ₂

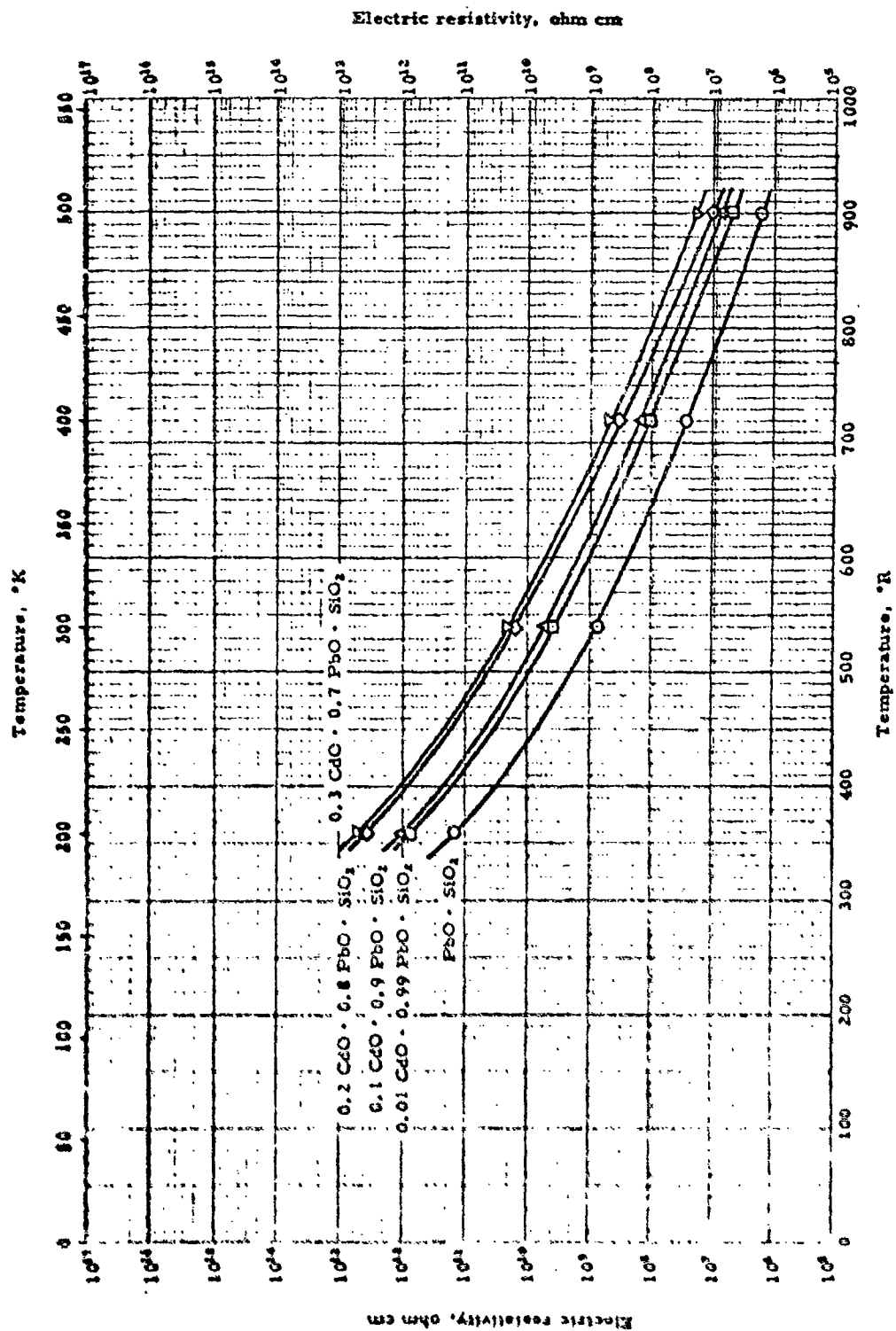


ELECTRIC RESISTIVITY -- BARIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- BARIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref	Investigator	Ref	Range, °K	Material Composition	Test Method	Remarks
1	Strouse, E. W., Moore, D. C. et al.	14-69	852-1212	0.01 BaO · 0.99 PbO · SiO ₂	Potential drop; DC reversal; temp. by Fe-Constant thermo- couple	Made from reagent grade materials; ground, melted, cast, annealed overnight, ground flat. Heated at 10 °C/min
2	Idid.	14-69	852-1212	0.1 BaO · 0.9 PbO · SiO ₂	Same as above	Same as above
3	Idid.	14-69	852-1212	0.2 BaO · 0.8 PbO · SiO ₂	Same as above	Same as above
4	Idid.	14-69	852-1212	0.3 BaO · 0.7 PbO · SiO ₂	Same as above	Same as above
5	Idid.	14-69	852-1212	0.4 BaO · 0.6 PbO · SiO ₂	Same as above	Same as above



60-784
WADC TR 58-476 785

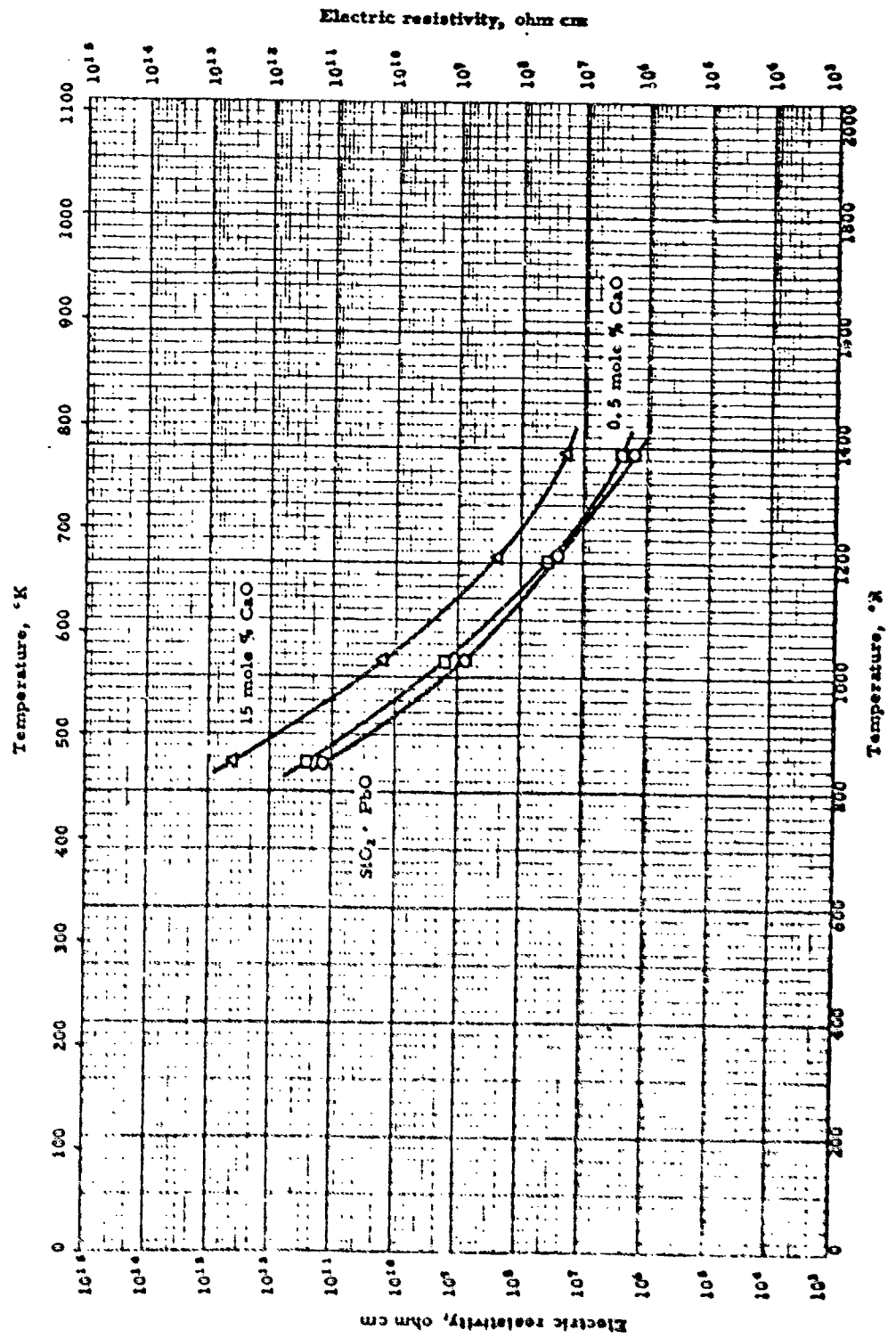
ELECTRIC RESISTIVITY -- CADMIUM LEAD SILICATE GLASS

VII - C - 1 -

ELECTRIC RESISTIVITY -- CADMIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
0	National Bureau of Standards	53-143	360-900	PbO · SiO ₂	Potential drop; DC reversal	
□	Did.	53-143	360-900	0.01 CdO · 0.99 PbO · SiO ₂	Same as above	
△	Did.	53-143	360-900	0.1 CdO · 0.9 PbO · SiO ₂	Same as above	
◇	Did.	53-143	360-900	0.2 CdO · 0.8 PbO · SiO ₂	Same as above	
▽	Did.	53-143	360-900	0.3 CdO · 0.7 PbO · SiO ₂	Same as above	

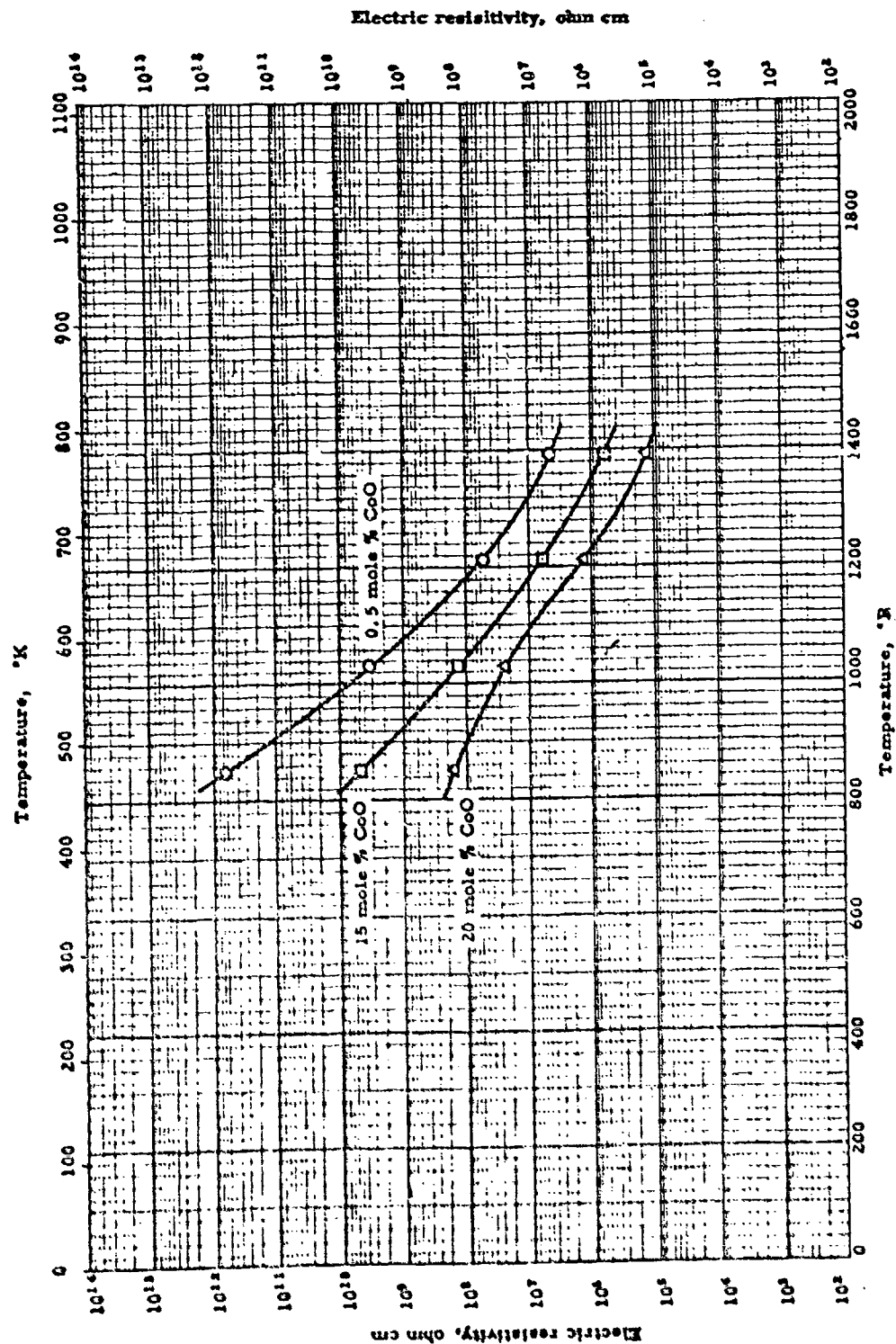


ELECTRIC RESISTIVITY -- CALCIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- CALCIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Sym Sol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Struss, S. W., Moore, D. G. et al.	53-143 also 56-69	852-1392	SiO ₂ + PbO	Potential drop, DC rever- sal. Sample temperature by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min.
□	Did.	53-143 also 56-69	852-1392	50.0% SiO ₂ ; 49.5% PbO; 0.5% CaO (Mole %)	Same as above	Same as above
Δ	Did.	53-143 also 56-69	852-1392	50.0% SiO ₂ ; 35% PbO; 15% CaO (Mole %)	Same as above	Same as above

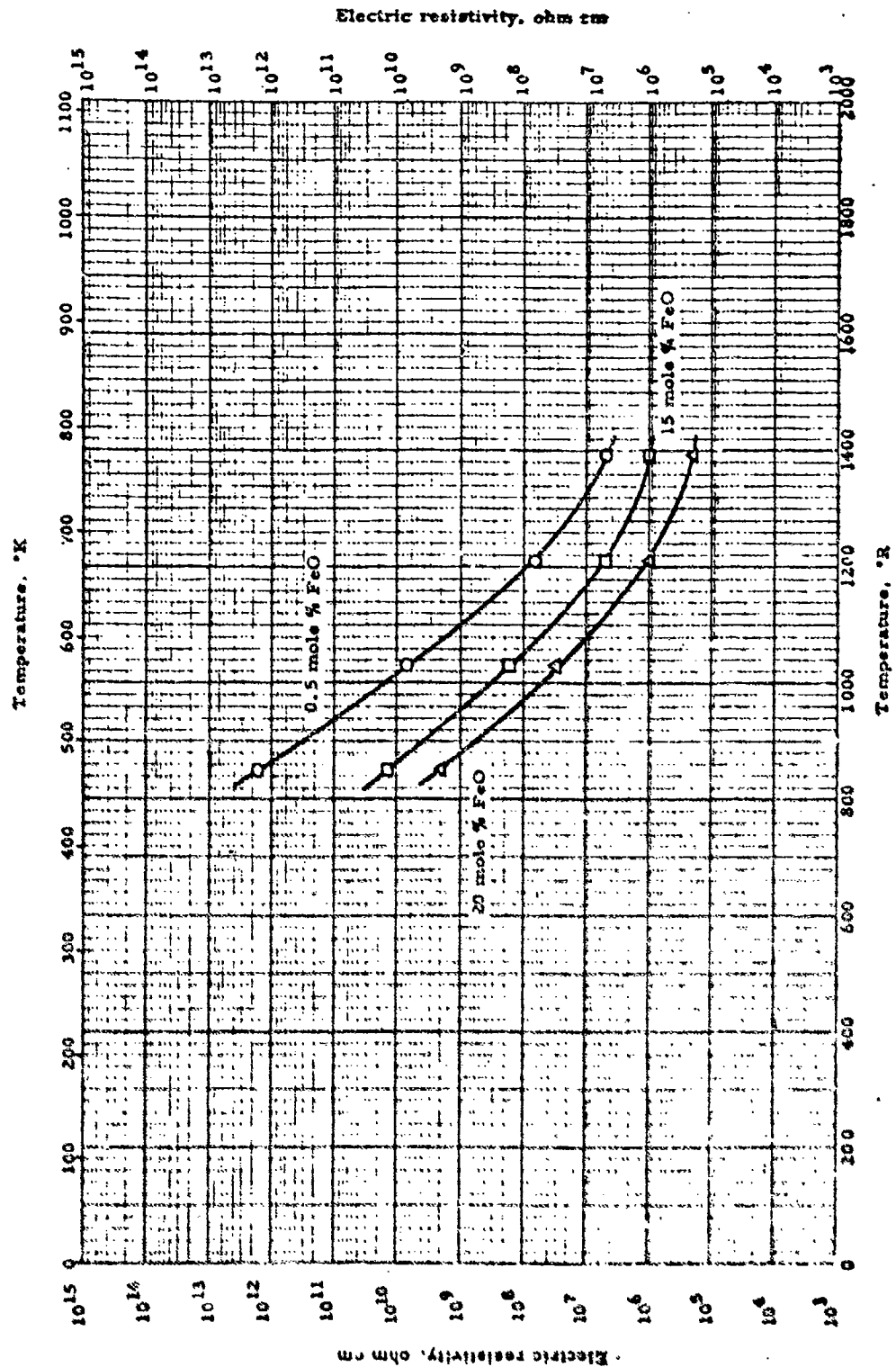


ELECTRIC RESISTIVITY -- COBALT-LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- COBALT-LEAD SILICATE GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Strauss, B. W., Moore, D. G. et al.	56-69 also 54-145	852-1392	50.0% SiO ₂ ; 49.5% PbO; 0.5% CoO (Mole %)	Potential drop; DC re- versal; sample temp. by Fe-Const. thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min.
□	Ibid.	56-69 also 54-145	852-1392	50.0% SiO ₂ ; 35% PbO; 15% CoO (Mole %)	Same as above	Same as above
△	Ibid.	56-69 also 54-145	852-1392	50.0% SiO ₂ ; 30% PbO; 20% CoO (Mole %)	Same as above	Same as above



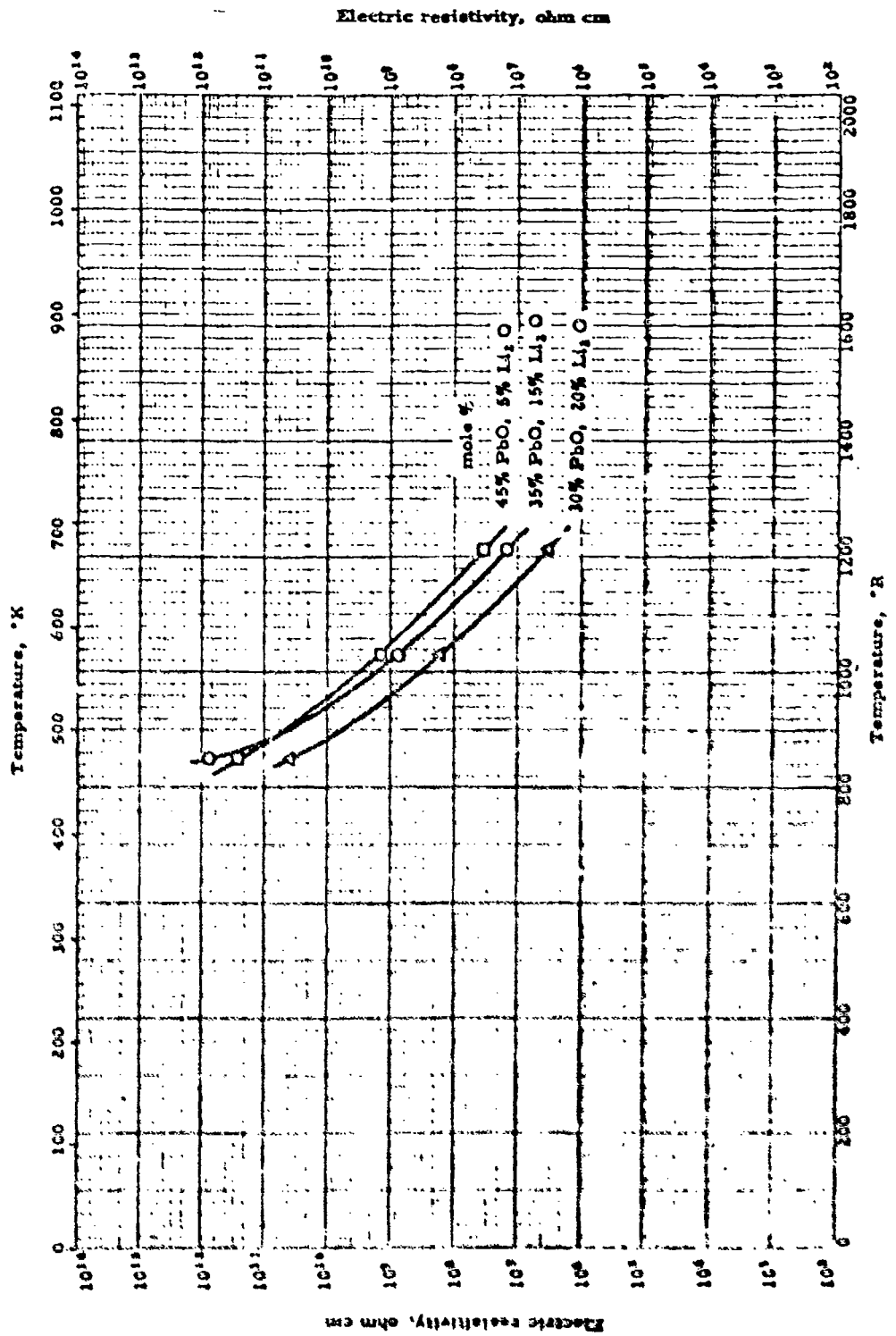
60-663
WADC TR 54-476 791

VII - C - 1 - B

ELECTRIC RESISTIVITY -- IRON LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-69	Strauss, S. W., Moore, D. G. et al.	852-1392	50.0% SiO ₂ ; 49.5% PbO; 0.5% FeO (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Constant thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min
56-69	Did.	852-1392	50.0% SiO ₂ ; 35% PbO; 15% FeO (Mole %)	Same as above	Same as above
56-69	Did.	852-1392	50.0% SiO ₂ ; 30% PbO; 20% FeO (Mole %)	Same as above	Same as above



60-582

WADC TR 58-476

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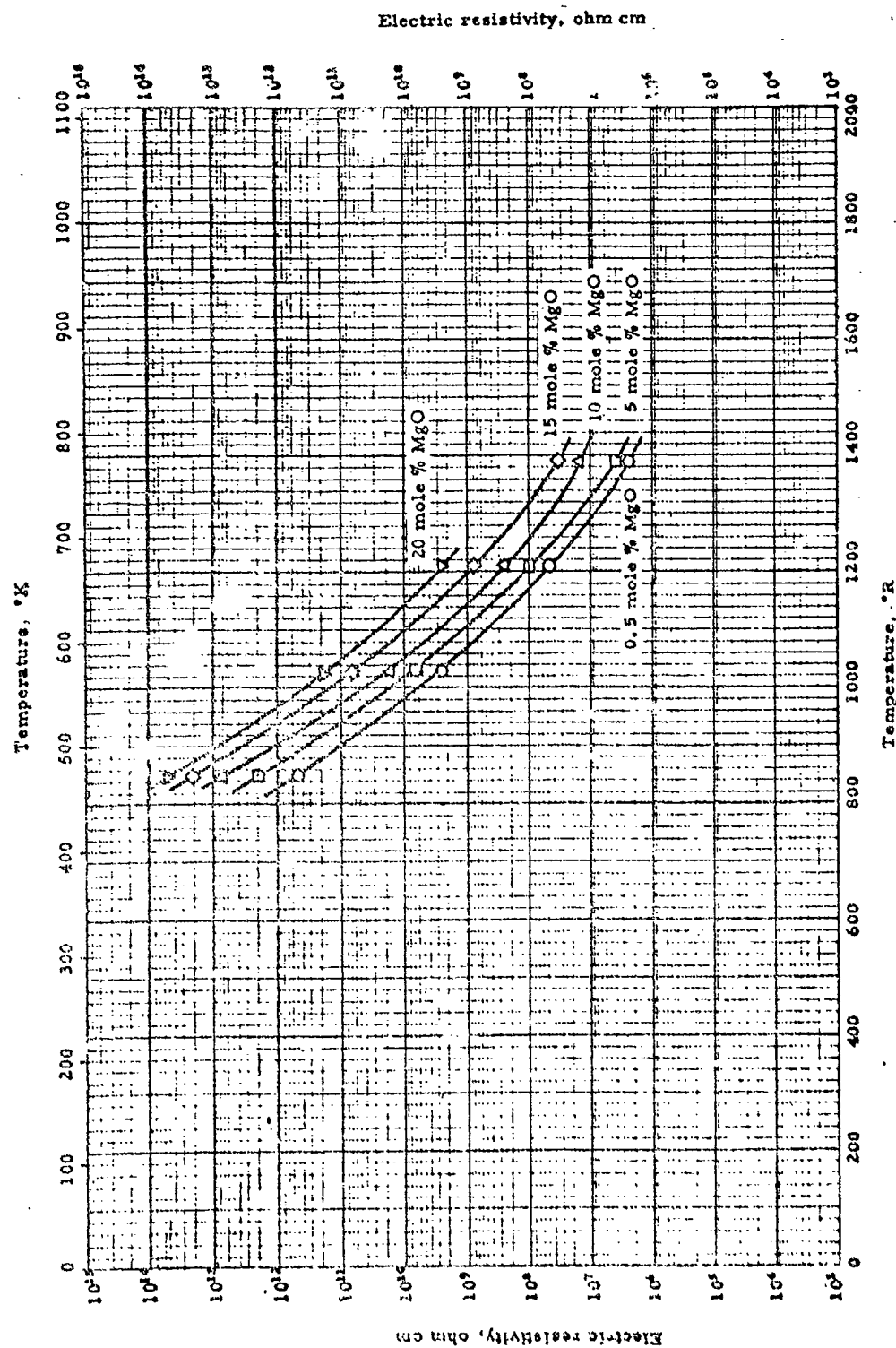
VII - C - 1 - a

ELECTRIC RESISTIVITY -- LITHIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- LITHIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-69	Stevens, E. W., Moore, D. G. et al.	852-1212	50% SiO ₂ ; 15% PbO; 15% Li ₂ O (Mole %)	Potential drop; DC re- versal; sample temp. by Fe-Const. thermoc- ouple	Ground from reagent grade chemicals, melted, cast, annealed over night, ground flat, heated at 10° C/min.
56-69	Did.	852-1212	50% SiO ₂ ; 45% PbO; 5% Li ₂ O (Mole %)	Same as above	Same as above
56-69	Did.	852-1212	50% SiO ₂ ; 30% PbO; 15% Li ₂ O (Mole %)	Same as above	Same as above; auth. re- port additional detailed data for system (0.01 - 0.4) Li ₂ O - (0.99 - 0.6) PbO - SiO ₂



60-783
WADC TR 58-476

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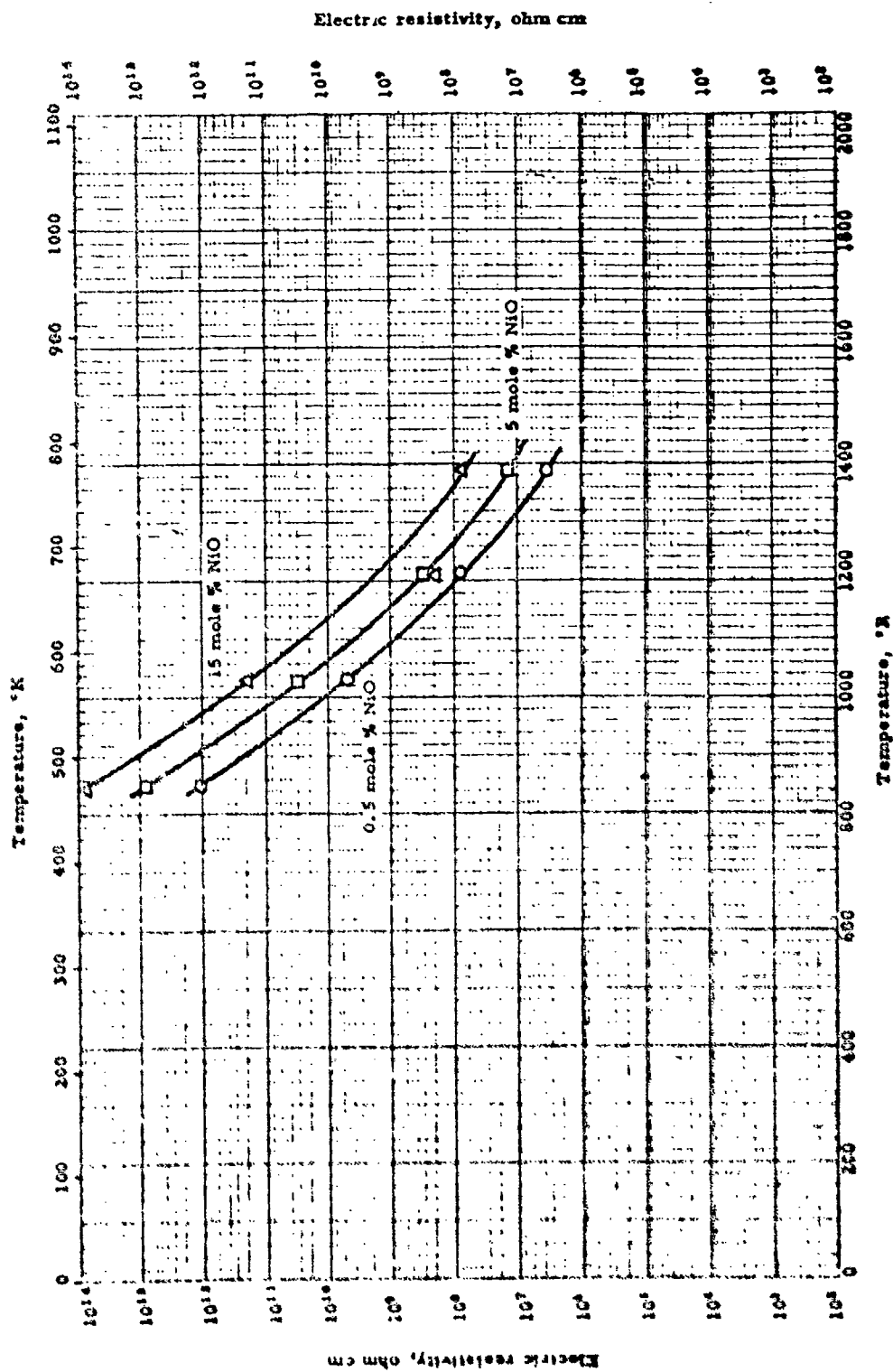
VII - C - 1 - m

ELECTRIC RESISTIVITY -- MAGNESIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- MAGNESIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °E	Material Composition	Test Method	Remarks
C	Strassler, S. W., Moore, D. G. et al.	56-69 also 53-143	352-1392	$\text{SiO}_2 \cdot 0.99 \text{ PbO} \cdot 0.01 \text{ MgO}$	Potential drop, DC reversal; sample temp. by Fe-Conet thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat Heated at 16°C/min .
C	D14.	56-69 also 53-143	352-1392	$\text{SiO}_2 \cdot 0.9 \text{ PbO} \cdot 0.1 \text{ MgO}$	Same as above	Same as above
A	D14.	56-69 also 53-143	352-1392	$\text{SiO}_2 \cdot 0.8 \text{ PbO} \cdot 0.2 \text{ MgO}$	Same as above	Same as above
O	D14.	56-69 also 53-143	352-1392	$\text{SiO}_2 \cdot 0.7 \text{ PbO} \cdot 0.3 \text{ MgO}$	Same as above	Same as above
G	D14.	56-69 also 53-143	352-1392	$\text{SiO}_2 \cdot 0.6 \text{ PbO} \cdot 0.4 \text{ MgO}$	Same as above	Same as above



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737

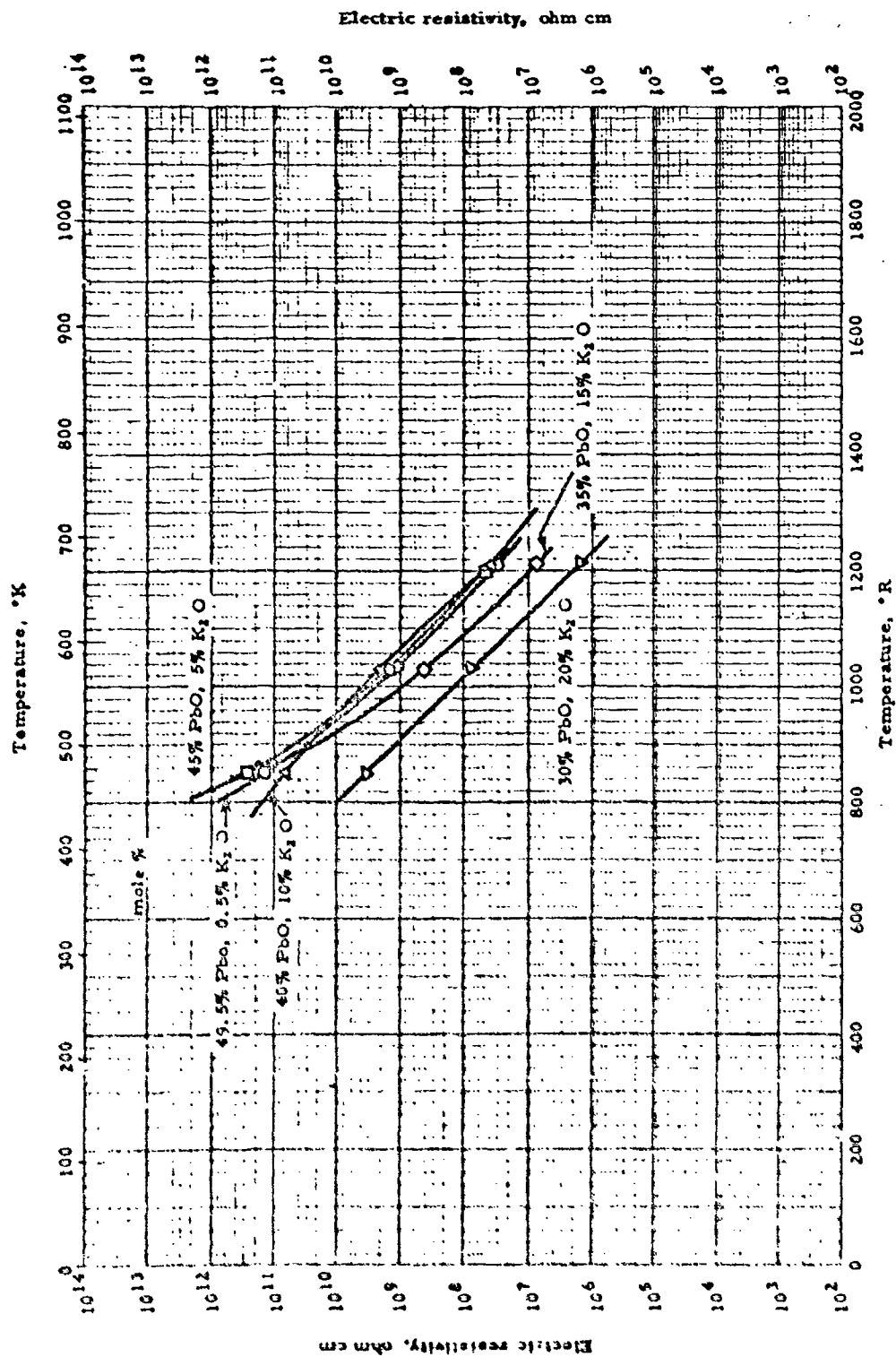
VII - C - 1 - m

ELECTRIC RESISTIVITY -- NICKEL-LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- NICKEL-LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	54-145 also 56-69	852-1392	50.0% SiO ₂ ; 49.5% PbO; 0.5% NiO (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Const. thermocouple	
□	Ibid.	54-145 also 56-69	852-1392	50.0% SiO ₂ ; 45% PbO; 5% NiO (Mole %)	Same as above	
△	Ibid.	54-145 also 56-69	852-1392	50.0% SiO ₂ ; 35% PbO; 15% NiO (Mole %)	Same as above	

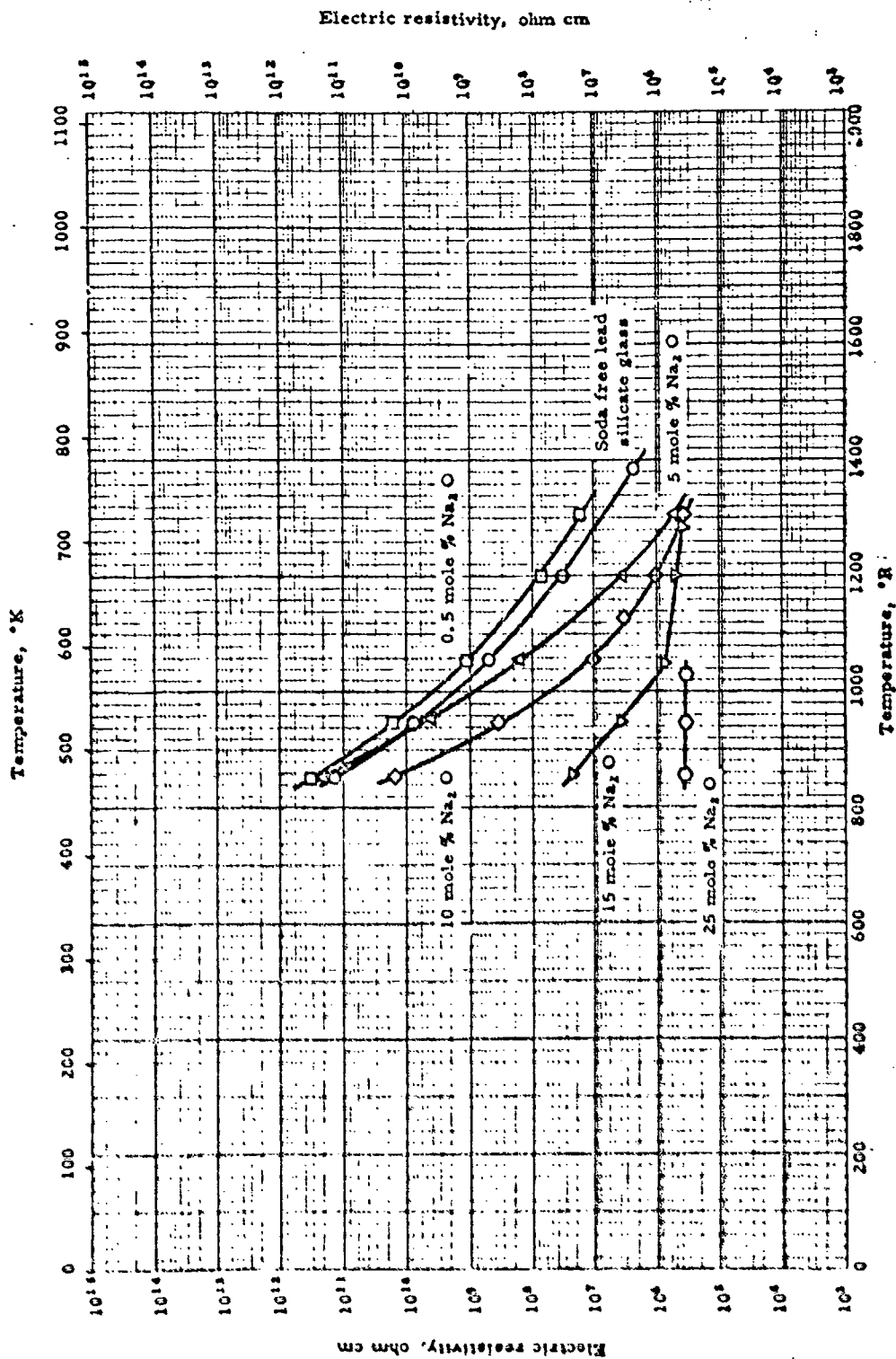


ELECTRIC RESISTIVITY -- POTASSIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- POTASSIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
56-69	Strauss, S. W., Moore, D. G. et al.	56-69	852-1212	50.0% SiO ₂ ; 49.5% PbO; 0.5% K ₂ O (mole %)	Potential drop; DC reversal; sample temp. by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min
56-69	D14.	56-69	852-1212	50.0% SiO ₂ ; 45% PbO; 5% K ₂ O (mole %)	Same as above	Same as above
56-69	D14.	56-69	852-1212	50.0% SiO ₂ ; 40% PbO; 10% K ₂ O (mole %)	Same as above	Same as above
56-69	D14.	56-69	852-1212	50.0% SiO ₂ ; 35% PbO; 15% K ₂ O (mole %)	Same as above	Same as above
56-69	D14.	56-69	852-1212	50.0% SiO ₂ ; 30% PbO; 20% K ₂ O (mole %)	Same as above	Same as above



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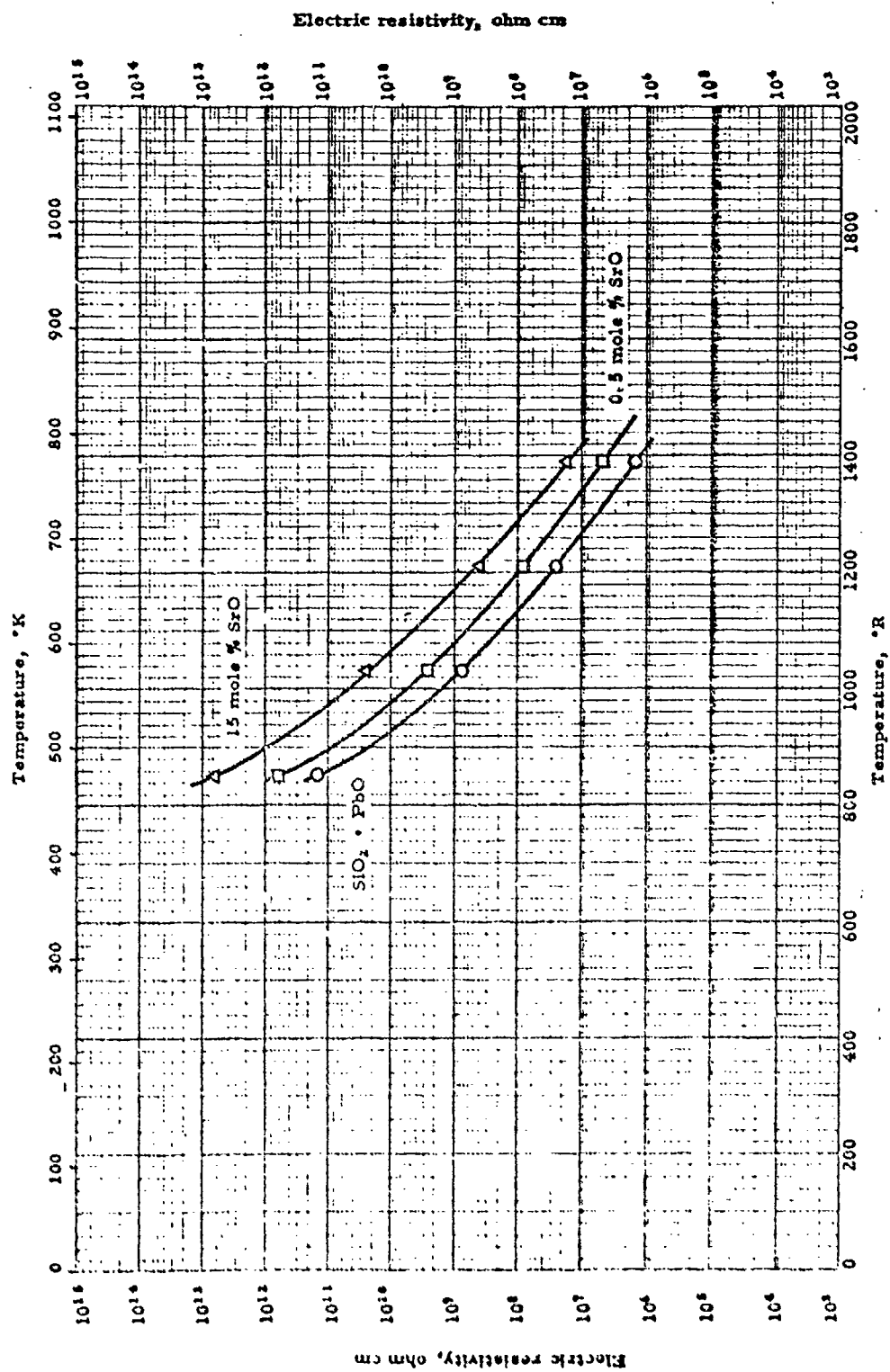
ELECTRIC RESISTIVITY -- SODIUM LEAD SILICATE GLASS

VII - C - 1 - m

ELECTRIC RESISTIVITY -- SODIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

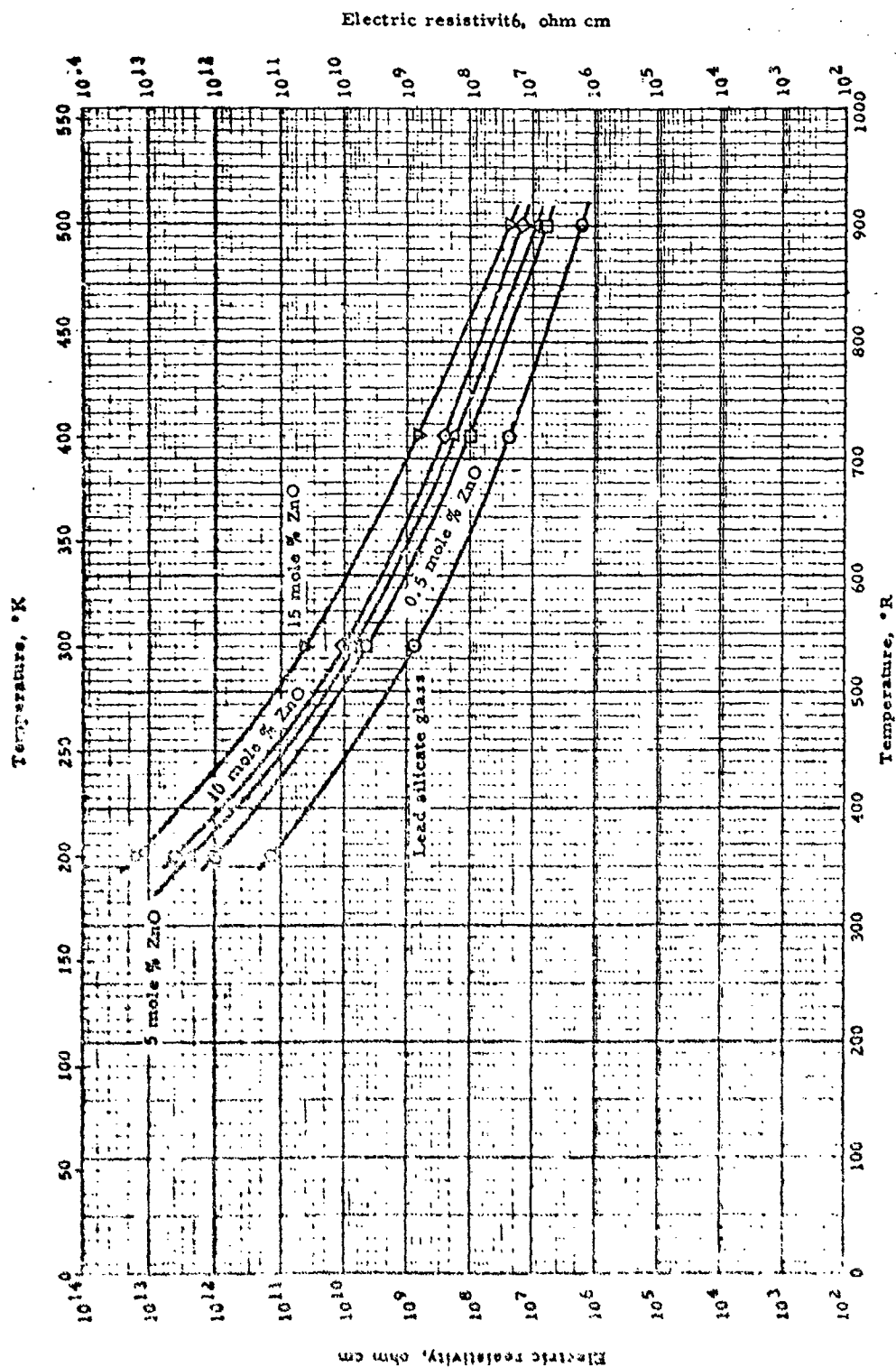
	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Strauss, S. W., Moore, D. G. et al.	56-69 also 53-96 also 53-142	857-1392	50% SiO ₂ ; 50% PbO (Mole %)	Potential drop; DC reversal	
□	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO ₂ ; 49.5% PbO; 0.5% Na ₂ O (Mole %)	Same as above	
△	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO ₂ ; 45% PbO; 5% Na ₂ O (Mole %)	Same as above	
◇	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO ₂ ; 40% PbO; 10% Na ₂ O (Mole %)	Same as above	
7	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO ₂ ; 35% PbO; 15% Na ₂ O (Mole %)	Same as above	
○	Ibid.	56-69 also 53-96 also 53-142	857-1026	50% SiO ₂ ; 25% PbO; 25% Na ₂ O (Mole %)	Same as above	Auth. report additional detailed data for system (1-0.2)PbO; (0-0.8)Na ₂ O; 0 SiO ₂



ELECTRIC RESISTIVITY -- STRONTIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Schrause, S. W., Moore, D. G., et al.	56-69 also 53-143	352-1392	SiO ₂ - PbO	Potential drop, D.C. reversal; sample temp. by Fe-Const. thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min.
□	Ibid.	56-69 also 53-143	852-1392	50.0% SiO ₂ ; 49.5% PbO; 0.5% SrO (Mole %)	Same as above	Same as above
△	Ibid.	56-69 also 53-143	352-1392	50% SiO ₂ ; 35% PbO; 15% SrO (Mole %)	Same as above	Same as above

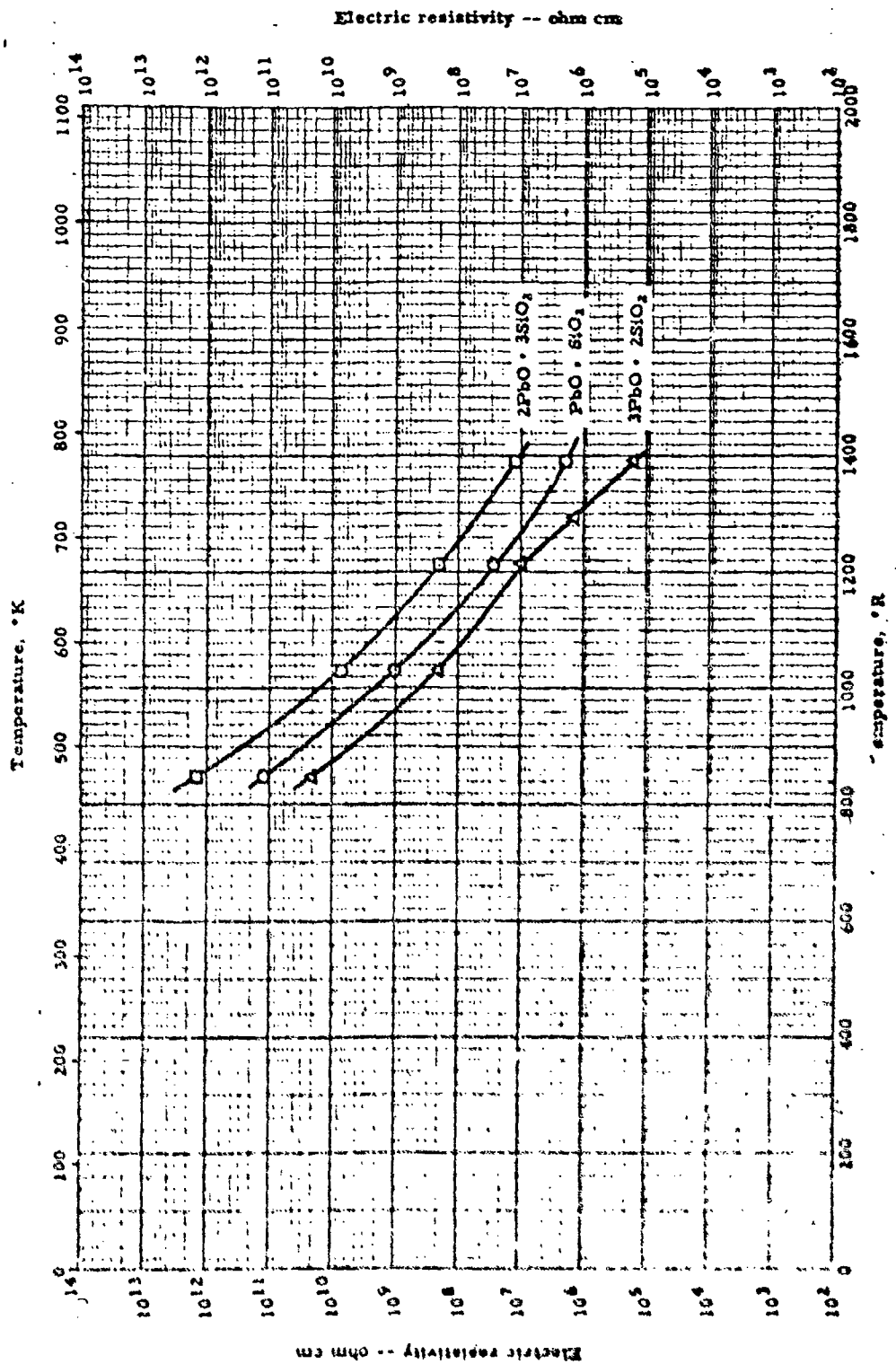


ELECTRIC RESISTIVITY -- ZINC LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- ZINC LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	National Bureau of Standards	53-143	360-500	SiO ₂ - PbO	Potential drop; DC reversal	
□	Ibid.	53-143	360-500	50.0% SiO ₂ ; 49.5% PbO; 0.5% ZnO (Mole %)	Same as above	
△	Ibid.	53-143	360-500	50% SiO ₂ ; 45% PbO; 5% ZnO (Mole %)	Same as above	
◇	Ibid.	53-143	360-500	50% SiO ₂ ; 40% PbO; 10% ZnO (Mole %)	Same as above	
▽	Ibid.	53-143	360-900	50% SiO ₂ ; 35% PbO; 15% ZnO (Mole %)	Same as above	

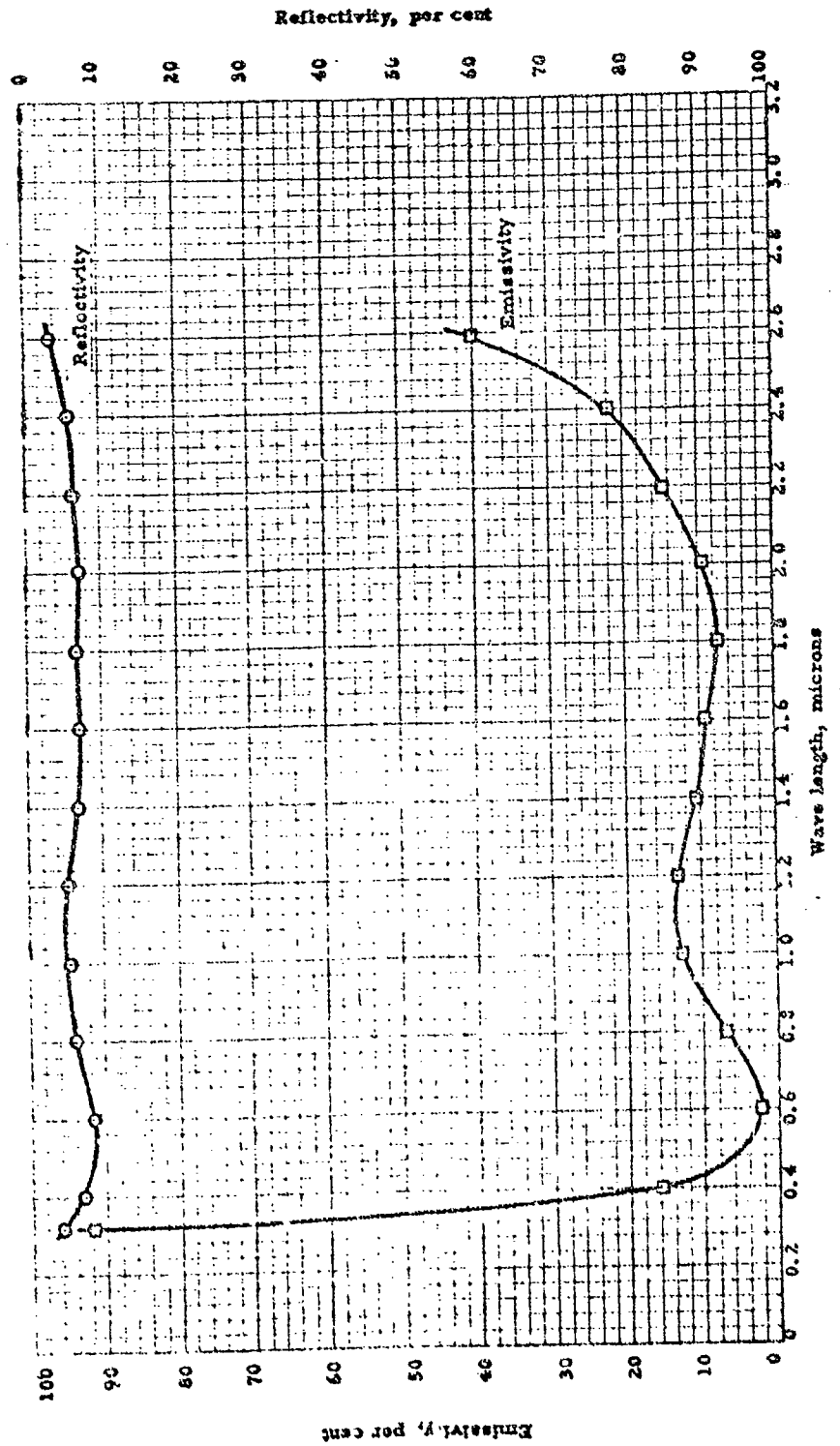


ELECTRIC RESISTIVITY -- LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

SYN	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	National Bureau of Standards	53-96	852-1392	PbO • SiO ₂	Potential drop; DC reversal	High purity material
□	Ibid.	53-96	352-1392	2PbO • 3SiO ₂	Same as above	Same as above
△	Ibid.	53-96	852-1392	1PbO • 2SiO ₂	Same as above	Same as above

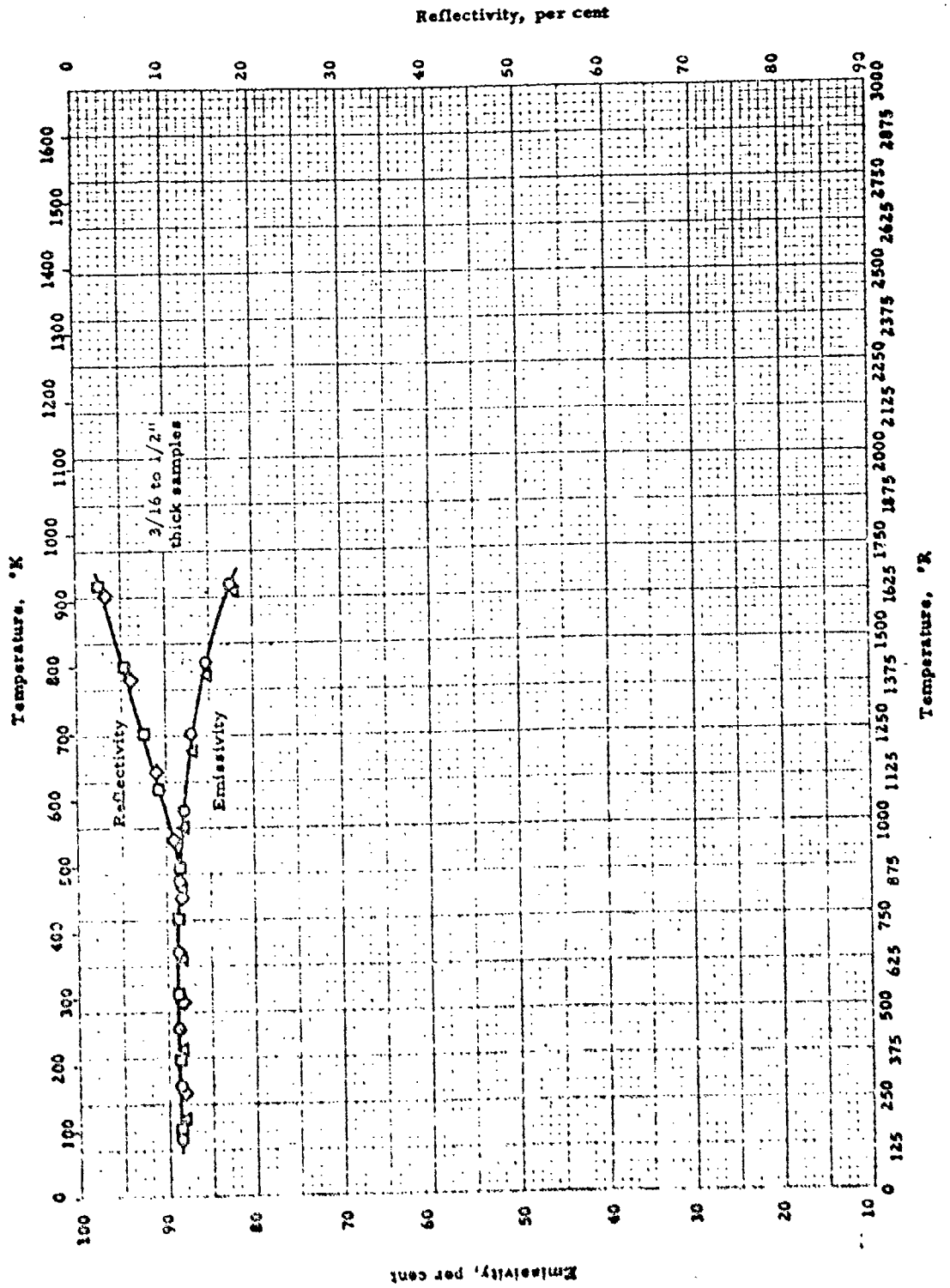


SPECTRAL EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

SPECTRAL EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

REFERENCE INFORMATION

Sum Total	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Olson, O. H. and Morris, J. C.	59-1	Room	Corning No. 1723 Glass	Spectral reflectivity at 9°; sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detec- tor	1/2 in. thick sample
0	Idid.	59-1	Room	Same as above	Spectral emissivity: meas. spectral reflecti- vity as above, and spec- tral transmissivity: comparative: radiation through sample com- pared with incident radia- tion by integrating sphere	Same as above Emissivity = 1 - reflectivity - transmissivity



EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Gilson, O. H. and Morris, J. C.	59-1	160-1660	Corning No. 1723 aluminum silicate glass	Total normal emissivity: comparative; surface brightness compared with that of a black body hole using thermopile. Sample temp. by thermocouple	1/2 in. sample in air
□	Ibid.	59-1	160-1660	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1-emissivity-transmissivity
△	Ibid.	59-1	160-1660	Same as above	Total normal emissivity: comparative; surface brightness compared with that of a black body hole using thermopile. Sample temp. by thermocouple	3/16 in. sample in air
◇	Ibid.	59-1	160-1660	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1-emissivity-transmissivity

Symbol	Nominal Composition, %				Density		Deformation Temperature	
	B ₂ O ₃	BaO	CaO	SrO	lb m /ft ³	g/cm ³	°R	°K
○	68.4	31.6			167.2	2.678	1464	813.2
	64.2	35.8			175.6	2.813	1536	853.2
	59.4	40.6			187.0	2.996	1563	868.2
	54.9	45.1			199.2	3.190	1583	879.2
	52.5	47.5			205.3	3.289	1583	879.2
	49.4	50.6			214.1	3.429	1590	883.2
□	44.6	55.4			226.6	3.630	1588	882.2
	75.0		25.0		155.1	2.484	1676	931.2
	73.0		27.0		158.0	2.531	1689	938.2
	69.8		30.2		162.0	2.595	1694	941.2
△	67.7		32.3		164.4	2.633	1696	942.2
	71.0			29.0	165.4	2.649	1597	887.2
	70.6			29.4	167.1	2.677	1610	894.2
	65.6			34.4	174.9	2.802	1635	908.2
	64.5			35.5	178.1	2.852	1640	911.2
	62.7			37.3	183.0	2.931	1646	914.2
◇	60.4			39.6	187.7	3.007	1660	922.2
	57.4			42.6	193.6	3.101	1660	922.2
	100.0				116.1	1.859		

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PROPERTIES OF ALKALINE EARTH BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
56-157	Shermer, H. F.	56-157	528 1464-1588	B ₂ O ₃ + BaO glass system	p: not given Deformation temp: by maximum on thermal expansion curve, AL/L: Fizeau type interferometer	Made from reagent grade materials. Melted at 1300°C, cast, annealed 3 hr, at 590°C, cooled at 3°C/hr. to 500°C, furnace cooled 2°C/min, rise for AL/L test
56-157	Idid.	56-157	528 1676-1690	B ₂ O ₃ + CaO glass system	Same as above	Same as above
56-157	Idid.	56-157	528 1597-1660	B ₂ O ₃ + SrO glass system	Same as above	Same as above
56-157	Idid.	56-157	528	Fused B ₂ O ₃	Same as above	Same as above

Symbol	Material Composition, mol %		Density		Softening Temperature	
	Na ₂ O	B ₂ O ₃	Al ₂ O ₃	lb m/ft ³	g/cm ³	[°] R [°] K
O	15	75	10	131.7	2.109	
	22.5	67.5	10	136.4	2.185	
	25	65	10	138.4	2.217	
	30	60	10	143.3	2.295	
	20	65	15	137	2.19	
□	22.5	65	12.5	139	2.22	
	25	65	10	139	2.23	
	27.5	65	7.5	144	2.300	
	30	65	5	146	2.34	
	32.5	65	2.5	149	2.38	
Δ	35	65	0	150	2.400	
	20	65	15			1455 808
	22.5	65	12.5			1449 805
	25	65	10			1439 799
	27.5	65	7.5			1433 796
	30	65	5			1429 794
	32.5	65	2.5			1426 792

PROPERTIES OF SODIUM BOROALUMINATE GLASS

PROPERTIES OF SODIUM BOROALUMINATE GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	Room	$\text{Na}_2\text{O} + \text{B}_2\text{O}_3 + \text{Al}_2\text{O}_3$ series	p: weight in air and in xylene	Corrected for loss in weight of wire immersed and for buoyancy of air
□	Chandappa, N. and Simpson, H. E.	51-83	499	$\text{Na}_2\text{O} + \text{B}_2\text{O}_3 + \text{Al}_2\text{O}_3$ series	p: weight in air and in CCl_4	
Δ	Idz.	51-83	1426-1455	Same as above	Softening temp.: not described here, refers to others	

Symbol	Material Composition, Wt%					Density	
	Li ₂ O	B ₂ O ₃	Al ₂ O ₃	BeO	MgO	lb _m /ft ³	g/cm ³
O	0.0	100.0				116.0	1.859
	1.1	93.9				117.3	1.880
	2.3	97.2				120.5	1.931
	4.5	95.5				127.7	1.983
	6.5	93.5				126.6	2.029
	8.0	92.0				130.0	2.084
	10.6	89.4				133.2	2.135
	12.9	87.1				136.9	2.194
	14.8	85.2				139.2	2.231
	4.34	80.87	14.79			129.4	2.073
□	6.45	67.15	26.40			136.5	2.187
	6.54	71.15	22.31			134.5	2.155
	6.70	78.07	15.23			131.3	2.103
	7.04	92.96				129.4	2.072
	9.21	75.09	15.70			134.0	2.147
	10.51	73.55	15.94			135.2	2.165
	11.87	71.94	16.19			136.7	2.190
	14.71	68.57	16.72			140.1	2.244
	17.74	64.97	17.29			142.2	2.278
	20.98	61.13	17.89			143.4	2.297
Δ	10.41	84.89		4.70		134.9	2.161
	13.47	81.66		4.87		138.1	2.212
	16.77	78.18		5.05		140.1	2.244
◇	4.66	92.20			3.14	129.1	2.068
	4.77	83.81			6.42	132.2	2.117
	4.88	85.25			9.87	141.8	2.271
	7.38	85.99			6.63	137.0	2.195
	10.18	82.96			6.86	142.2	2.278
	10.71	74.85			14.44	148.5	2.378

DENSITY -- LITHIUM BORATE GLASS

DENSITY -- LITHIUM BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Chariss, L., Capps, W. and Spencer, S.	55-139	537	$\text{Li}_2\text{O} + \text{B}_2\text{O}_3$ series	Weight in air and in kerosene	
□	Moore, H. and McMillan, P. W.	56-158	Room	$\text{Li}_2\text{O} + \text{B}_2\text{O}_3 + \text{Al}_2\text{O}_3$ series	Weight in air and in xylene	
△	EdA.	56-155	Room	$\text{Li}_2\text{O} + \text{B}_2\text{O}_3 + \text{BeO}$ series	Same as above	
◇	EdA.	56-158	Room	$\text{Li}_2\text{O} + \text{B}_2\text{O}_3 + \text{MgO}$ series	Same as above	

Symbol	Material Composition, Wt%				Density	
	MgO	B ₂ O ₃	Al ₂ O ₃	BeO	lb m/ft ³	g/cm ³
O	22.54	61.18	16.28		154.1	2.469
	25.70	49.94	24.36		155.6	2.492
	26.38	56.95	16.67		155.0	2.483
	28.54	54.50	16.96		155.7	2.494
	29.60	45.45	24.95		157.6	2.525
□	31.24	59.98	8.78		155.9	2.497
	27.8	61.6		10.6	150.1	2.405
	31.3	60.8		7.9	152.4	2.441
	32.7	56.4		10.9	153.1	2.452

60-758

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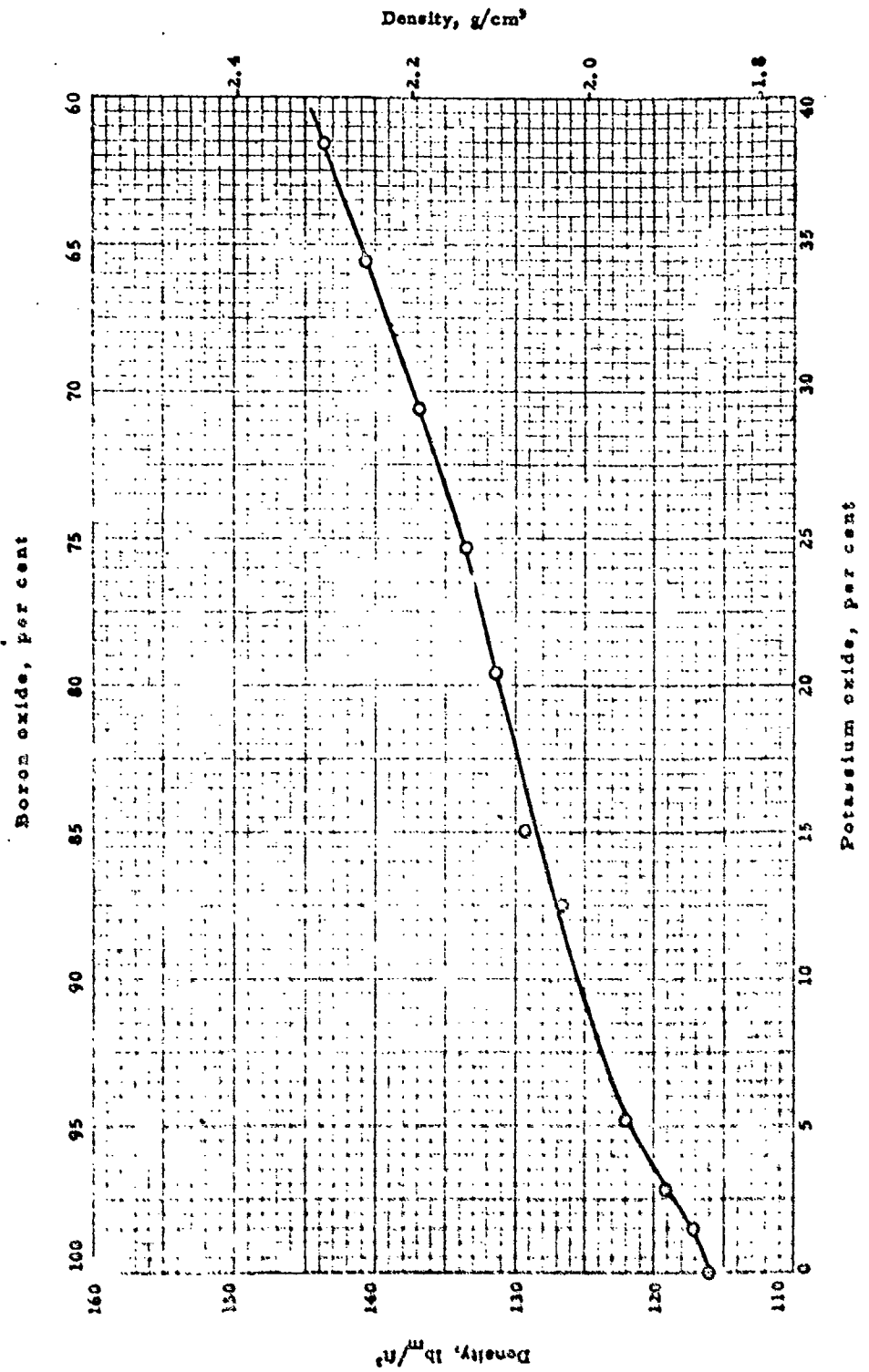
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DENSITY -- MAGNESIUM BORATE GLASS

DENSITY -- MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMullen, P. W.	56-158	Room	MgO + B ₂ O ₃ + Al ₂ O ₃ glass series	Weight in air and in xylene	
□	Ibid.	56-158	Room	MgO + B ₂ O ₃ + BeO glass series	Same as above	



DENSITY -- POTASSIUM BORATE GLASS

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DENSITY -- POTASSIUM BORATE GLASS

REFERENCE INFORMATION

Item No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Shartels, L., Capps, W. and Spinner, S.	51-134	537	K ₂ O + B ₂ O ₃ glasses	Weight in air and in kerosene	

Symbol	Material Composition, Wt%				Density	
	Na ₂ O	B ₂ O ₃	BeO	MgO	lb m/ft ³	g/cm ³
O	0.3	100.0			116.0	1.859
	0.9	99.1			117.4	1.881
	2.7	97.3			119.6	1.916
	5.6	94.4			123.3	1.976
	9.0	91.0			127.8	2.048
	14.2	85.8			132.4	2.122
	17.8	82.2			135.5	2.172
	22.4	77.6			140.9	2.258
□	26.4	73.6			144.1	2.309
	30.8	69.2			147.2	2.359
	31.8	68.2			148.4	2.378
	14.48	81.32	4.20		136.0	2.178
	19.42	76.35	4.23		137.0	2.194
	24.42	71.33	4.25		139.3	2.231
	29.49	65.23	4.28		143.5	2.298
	34.61	61.08	4.31		146.3	2.344
Δ	4.67	89.25		6.08	130.4	2.089
	9.20	87.80		3.00	130.1	2.084
	9.40	84.49		6.11	134.3	2.152
	9.62	81.00		9.38	138.2	2.213
	9.84	77.37		12.79	142.4	2.281
	10.07	73.55		16.38	145.8	2.336
	14.19	79.67		6.14	139.5	2.235
	19.02	74.79		6.19	143.2	2.293
	28.88	64.87		6.25	149.6	2.396

60-753

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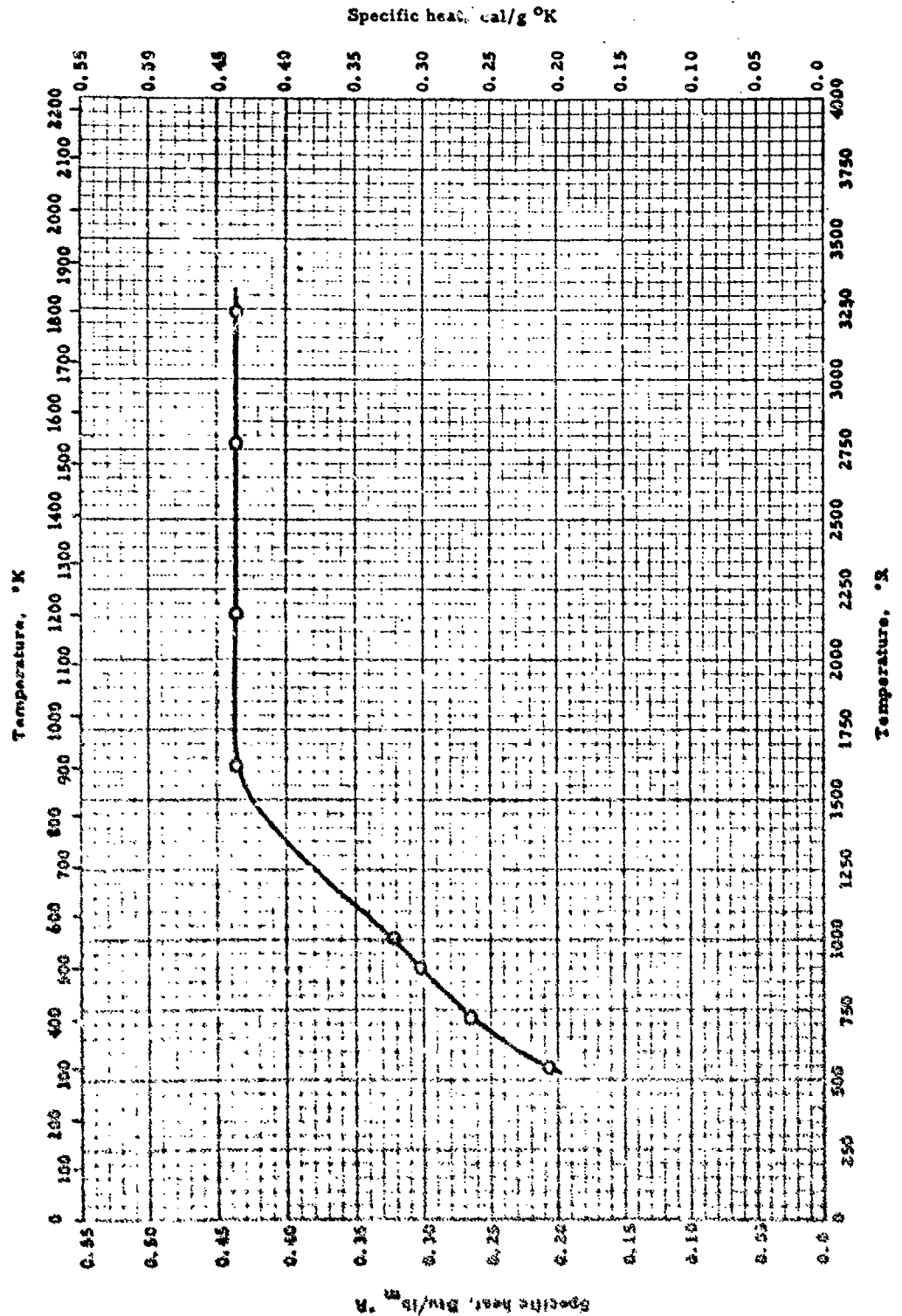
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DENSITY -- SODIUM BORATE GLASS

DENSITY -- SODIUM BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
53-139	Starrick, L., Chapman, W. and Spencer, S.	537	537	$\text{Na}_2\text{O} + \text{B}_2\text{O}_3$ glass series	Weight in air and in kerosene	
56-158	Moore, H. and McMillan, P. W.	Room	Room	$\text{Na}_2\text{O} + \text{B}_2\text{O}_3 + \text{BaO}$ glass series	Weight in air and in xylene	
56-158	2014.	Room	Room	$\text{Na}_2\text{O} + \text{B}_2\text{O}_3 + \text{MgO}$ glass series	Same as above	



SPECIFIC HEAT -- BORON OXIDE GLASS

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SPECIFIC HEAT -- BORON OXIDE CLASS

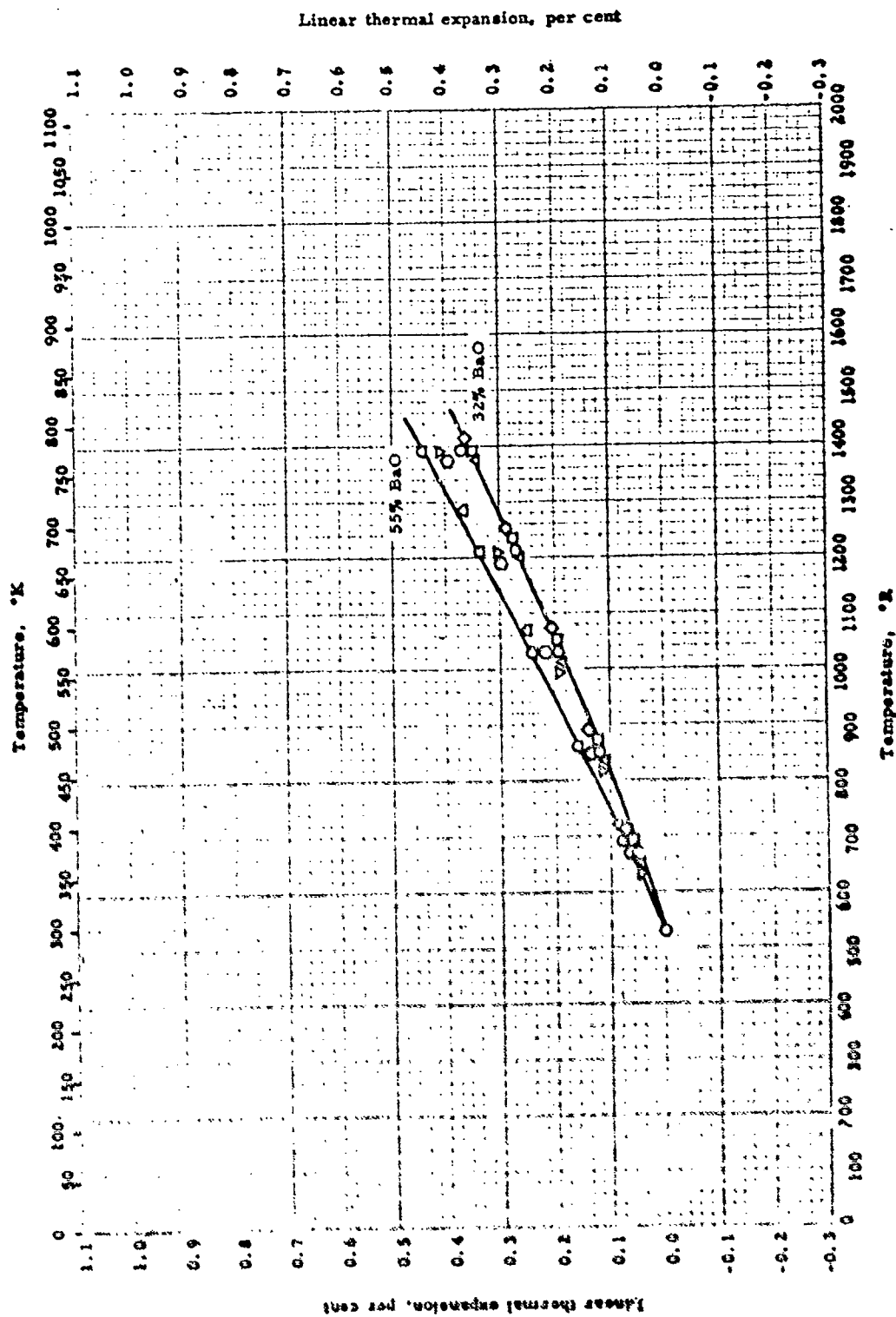
REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Southard, J. C.	41-25	687-3200	2 samples boron sesquioxide glass 99.30 - 99.79% B_2O_3 , 0.06 - 0.55% H_2O	Drop method, copper block calorimeter	

60-724

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LINEAR THERMAL EXPANSION -- BARIUM BORATE GLASS

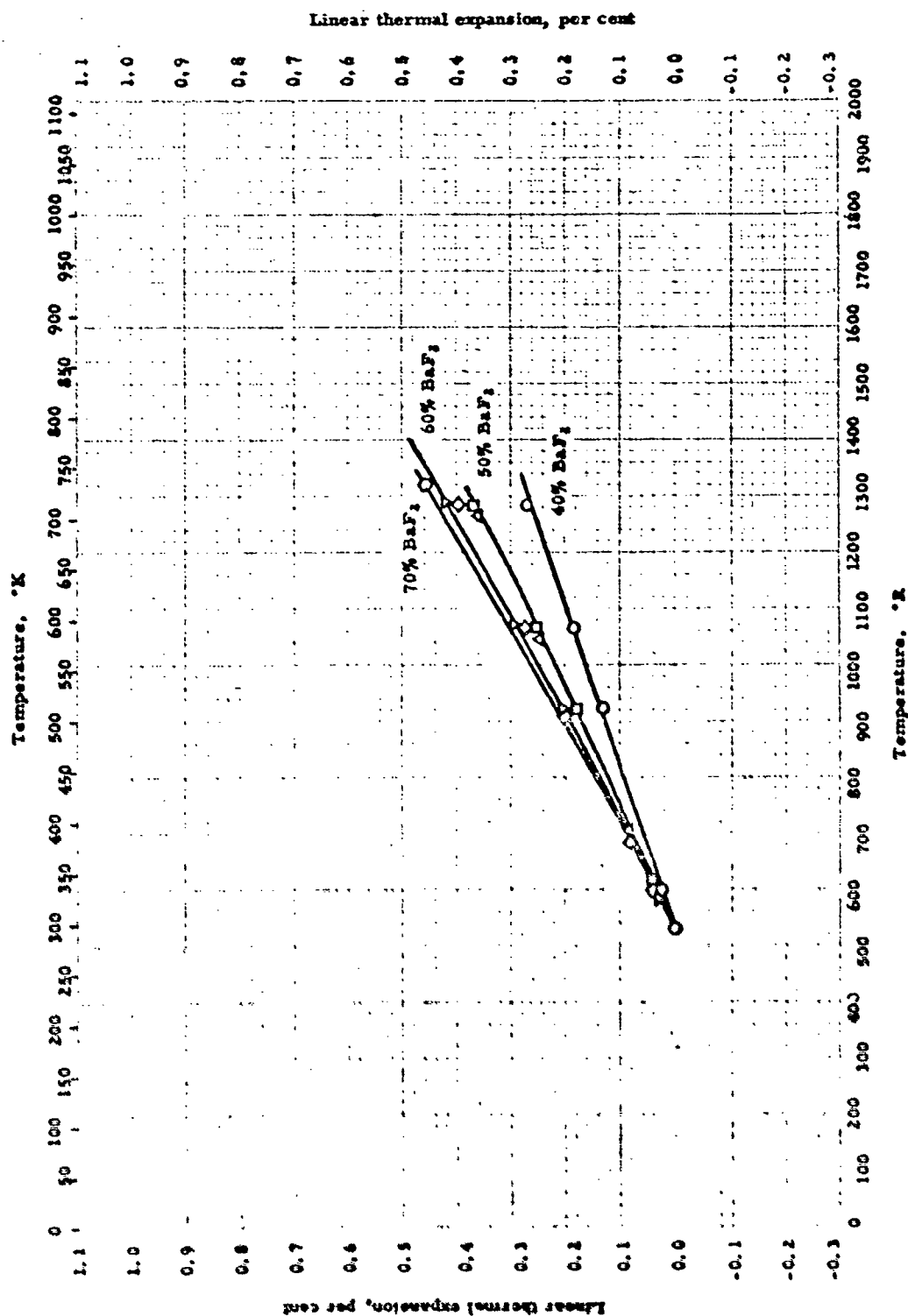
LINEAR THERMAL EXPANSION -- BARIUM BORATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-157	525-1392	68.4% B ₂ O ₃ ; 31.6% BaO	Interferometer, photographic recording	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr. at 590°C, cooled at 3°C/hr to 500°C, furnace cooled
□	D14.	56-157	525-1392	64.2% B ₂ O ₃ ; 35.8% BaO	Same as above	Same as above
△	D14.	56-157	525-1392	59.4% B ₂ O ₃ ; 40.6% BaO	Same as above	Same as above
○	D14.	56-157	525-1392	54.9% B ₂ O ₃ ; 45.1% BaO	Same as above	Same as above
▽	D14.	56-157	525-1392	52.5% B ₂ O ₃ ; 47.5% BaO	Same as above	Same as above
○	D14.	56-157	525-1392	50.6% B ₂ O ₃ ; 49.4% BaO	Same as above	Same as above
○	D14.	56-157	525-1392	44.6% B ₂ O ₃ ; 55.4% BaO	Same as above	Same as above
○	Isomized, T. and Total B.	52-135	525-1284	60% BaO; 40% B ₂ O ₃	Not given	Melted in alumina crucible at 1100°C from chemically pure BaF ₂ (from Merita Chemical Co.) and pure B ₂ O ₃ made by dehydrating H ₂ BO ₃ at 200-300°C.

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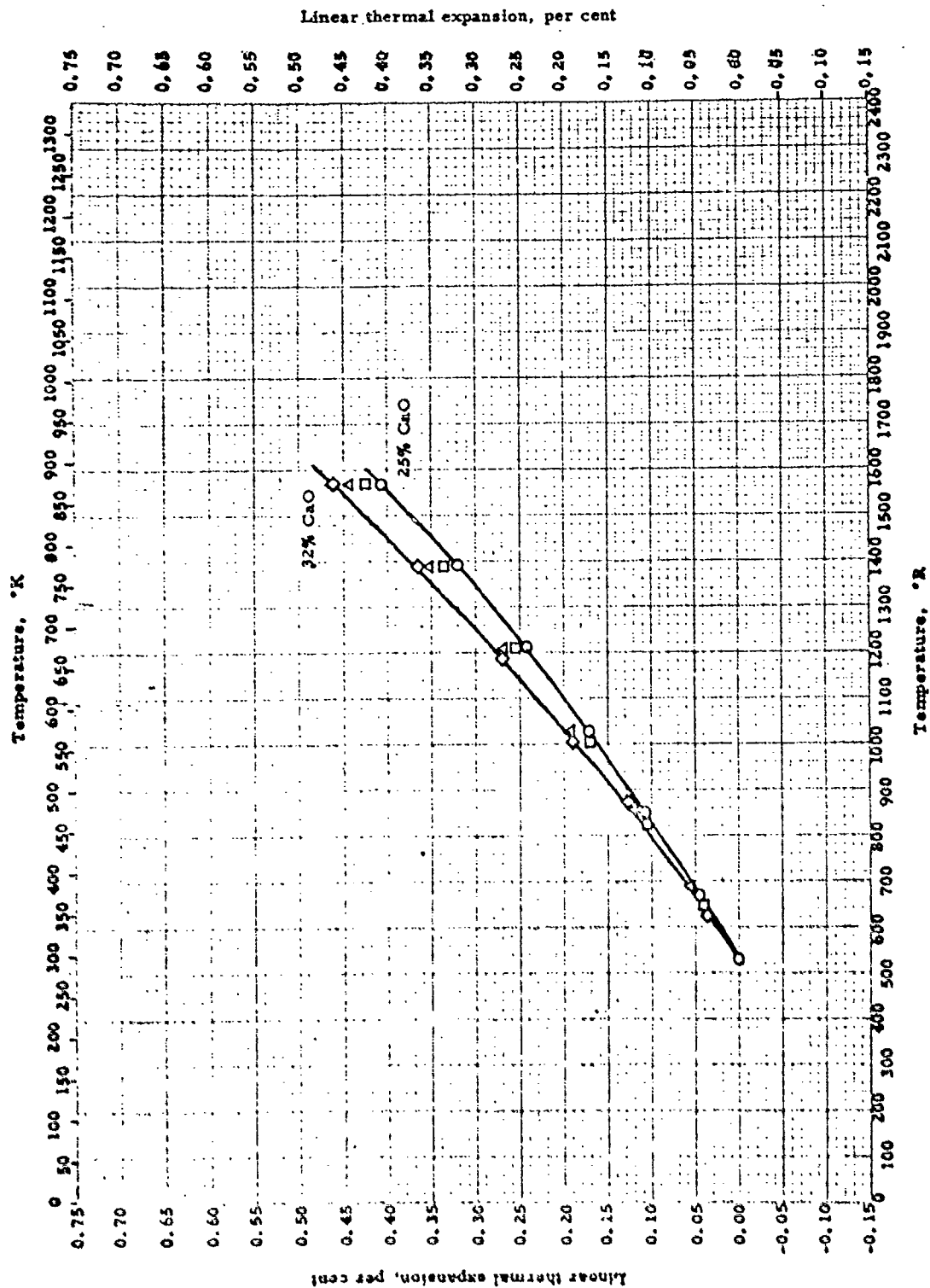


LINEAR THERMAL EXPANSION -- BARIUM FLUOBORATE GLASS

LINEAR THERMAL EXPANSION -- BARIUM FLUOROBORATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	52-	528-1284	60% B ₂ O ₃ ; 40% BaF ₂ . $\rho = 176 \text{ lb}_m/\text{ft}^3$	Dilatometer	B ₂ O ₃ from dehydrating H ₂ BO ₃ at 200-300 °C. BaF ₂ chemically pure. Melted in alumina crucible at 1100 °C
□	52-	528-1284	50% B ₂ O ₃ ; 50% BaF ₂ . $\rho = 190 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
△	52-	528-1284	60% BaO; 40% B ₂ O ₃ . $\rho = 235 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
◇	52-	528-1284	40% B ₂ O ₃ ; 60% BaF ₂ ; 20% BaO. $\rho = 217 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
▽	52-	528-1284	60% BaF ₂ ; 40% B ₂ O ₃ . $\rho = 208 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
○	52-	528-1220	70% BaF ₂ ; 30% B ₂ O ₃ . $\rho = 227 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above

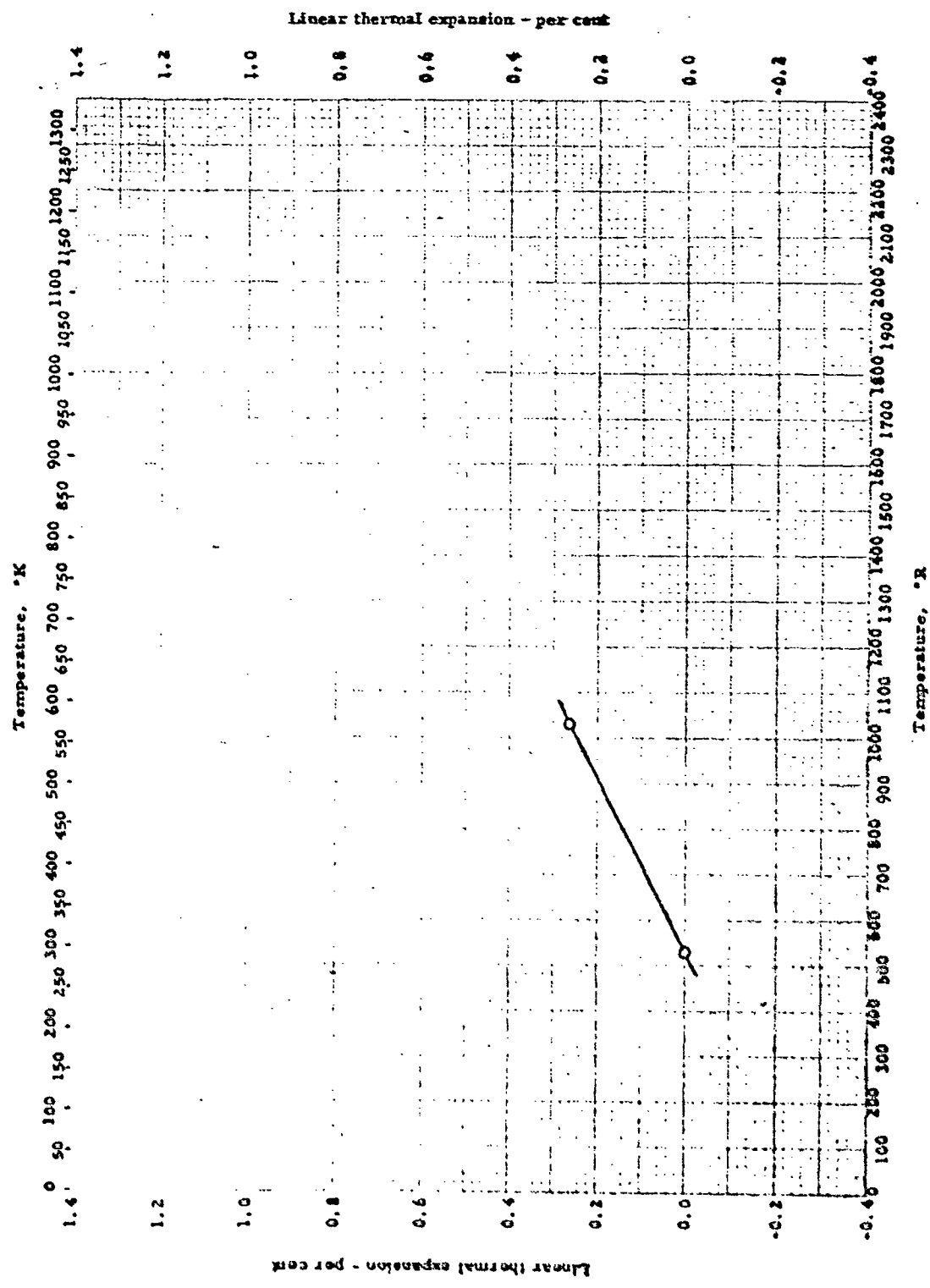


LINEAR THERMAL EXPANSION -- CALCIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- CALCIUM BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-157	Stearns, H. F.	528-1572	75% B ₂ O ₃ ; 25% CaO	Interferometer, photographic recording	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr. at 590°C, cooled at 3° C/hr. to 500°C, furnace cooled
56-157	Ibid.	528-1572	75% B ₂ O ₃ ; 27% CaO	Same as above	Same as above
56-157	Ibid.	528-1572	69.8% B ₂ O ₃ ; 30.2% CaO	Same as above	Same as above
56-157	Ibid.	528-1572	67.7% B ₂ O ₃ ; 32.3% CaO	Same as above	Same as above



59-696

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LINEAR THERMAL EXPANSION -- LEAD BORATE GLASS

LINEAR THERMAL EXPANSION -- LEAD BORATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O. Bischoff, F.	55-26	528-1032	76.2% PbO; 23.8 % P_2O_5	Not given	PbO · B_2O_3

Symbol	Material Composition						Average coefficient of linear expansion x 10 ⁶	
	B ₂ O ₃		Al ₂ O ₃		Li ₂ O		582-762°R	323-423°K
	Mol %	Wt %	Mol %	Wt %	Mol %	Wt %		
O	85	93.0			15	7.0	3.99	7.18
	80	85.3	5	7.8	15	6.9	3.70	6.67
	80	80.9	10	14.8	10	4.3	3.92	7.06
	75	78.1	10	15.2	15	6.7	3.83	6.89
	65	76.3	5	8.6	30	15.1	4.44	7.99
	70	75.1	10	15.7	20	9.2	4.01	7.22
	72.5	74.6	12.5	18.8	15	6.6	3.65	6.57
	67.5	73.6	10	15.9	22.5	10.5	4.17	7.50
	65	71.9	10	16.2	25	11.9	4.31	7.75
	70	71.2	15	22.3	15	6.5	3.74	6.73
	62.5	70.3	10	16.4	27.5	13.3	4.28	7.71
	60	68.6	10	16.7	30	14.7	4.47	8.04
	67	67.1	18	26.4	15	6.5	3.83	6.90
	57.5	66.8	10	17.0	32.5	16.2	4.77	8.58
	55	65	10	17.3	35	17.7	4.90	8.82
	55	61.2	15	24.5	30	14.3	4.58	8.24
	50	61.1	10	17.9	40	21.0	5.51	9.92
	50	54.2	20	31.8	30	14.0	4.56	8.21

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LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Sym. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	582-762	$\text{Li}_2\text{O} - \text{Al}_2\text{O}_3 - \text{B}_2\text{O}_3$ glasses	Not given	Annealed

Symbol	Material Composition						Average coefficient of of linear expansion $\times 10^6$ <u>582-762°R</u> <u>323-423°K</u>	
	B ₂ O ₃		Li ₂ O		BeO			
	Mol %	Wt %	Mol %	Wt %	Mol %	Wt %		
O	75	87.9	15	7.5	10	4.5	3.64	6.56
	70	84.9	20	10.4	10	4.7	3.78	6.81
	65	81.7	25	13.5	10	4.9	4.21	7.57
	60	78.2	30	16.8	10	5.0	4.78	8.61
□		70.23		17.82		11.95	<u>492-1032°R</u>	<u>273-578°K</u>
							5.5	9.9

LINEAR THERMAL EXPANSION -- LITHIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
56-156	Moore, H. and McMillan, P. W.	552-762	Li ₂ O - BeO - B ₂ O ₃ glasses	Not given	Annealed
51-81	Dick, A. E., Fitz, E. F., and Stewart, J. E.	492-1032	Lindemann x-ray transmitting glass. 70.23% B ₂ O ₃ ; 17.62% Li ₂ O; 11.95% BeO	Quartz differential dilata- tometer	

Symbol	Material Composition, %						Average coefficient of linear expansion $\times 10^6$	
	B ₂ O ₃		Li ₂ O		MgO		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	°R ⁻¹	°K ⁻¹
O	95.4	90	4.6	10			5.18	9.32
	92.2	85	4.7	10	3.1	5	4.04	7.28
	90.5	82.5	4.7	10	4.8	7.5	3.67	6.60
	90.3	80	9.7	20			4.06	7.31
	88.8	80	4.8	10	6.4	10	3.53	6.35
	86.7	75	9.9	20	3.4	5	3.82	6.88
	86.0	75	7.4	15	6.6	10	3.73	6.72
	85.2	75	4.9	10	9.9	15	3.50	6.30
	83.0	70	10.2	20	6.9	10	3.76	6.78
	81.5	70	5.0	10	13.5	20	3.40	6.12
	81.4	67.5	11.6	22.5	7.0	10	3.97	7.05
	79.0	65	10.4	20	10.6	15	3.89	7.00
	74.9	60	10.7	20	14.4	20	3.93	7.08
	70.5	55	11.0	20	18.5	25	4.06	7.31

60-551

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LINEAR THERMAL EXPANSION -- LITHIUM MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Syr. Sol.	Investigator	Ref.	Range, °R	Mat'ial Composition	Test Method	Remarks
0	Moore, H. and McMillan, P. J.	56-156	582-762	Li ₂ O - MgO - B ₂ O ₃ Series	Not given	Annealed

Symbol	Material Composition, %						Average coefficient of linear expansion $\times 10^6$	
	B ₂ O ₃		MgO		Al ₂ O ₃		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	°R ⁻¹	°K ⁻¹
O	61.2	55	22.5	35	16.3	10	2.84	5.11
	60.0	50	31.2	45	8.8	5	3.06	5.50
	59.1	52.5	24.4	37.5	16.5	10	2.82	5.08
	56.9	50	26.4	40	16.7	10	2.79	5.02
	54.5	47.5	28.5	42.5	17.0	10	2.78	5.00
	52.5	45	30.4	45	17.1	10	2.69	4.85

60-550

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LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	582-762	MgO - Al ₂ O ₃ - B ₂ O ₃ Series	Not given	Annealed

60-550

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Symbol	Material Composition						Average coefficient of linear expansion x 10 ⁶	
	B ₂ O ₃		MgO		BeO		582-762°R	323-423°K
	Mol%	Wt %	Mol %	Wt %	Mol %	Wt %	°R-1	°K-1
O	45	61.6	35	27.8	20	10.6	2.92	5.26
	45	60.8	40	31.3	15	7.9	2.53	4.56
	40	57.2	35	29.0	25	13.9	3.09	5.57
	40	56.4	40	32.7	20	10.9	3.06	5.50

60-761
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LINEAR THERMAL EXPANSION -- MAGNESIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- MAGNESIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Sym. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-170	582-762	MgO - BeO - B ₂ O ₃ series	Not given	Annealed

Symbol	Material Composition, mol %			Average coefficient of linear expansion $\times 10^6$	
	<u>B₂O₃</u>		<u>Na₂O</u>	<u>582-762°R</u>	<u>323-423°K</u>
			<u>Al₂O₃</u>		
O	80	20		5.33	9.59
	75	20	5	5.51	9.92
	75	15	10	5.19	9.34
	70	30		5.99	10.78
	70	20	10	5.66	10.18
	67.5	22.5	10	5.89	10.60
	65	30	5	6.28	11.30
	65	25	10	6.37	11.46
	65	20	15	5.99	10.79
	60	30	10	6.62	11.92
	55	30	15	6.65	11.97
	50	30	20	6.73	12.12
	40	40	20	8.02	14.44
	65	35		5.8	10.4
	65	32.5	2.5	5.2	9.4
□	65	30	5	5.0	9.0
	65	27.5	7.5	4.9	8.8
	65	25	10	4.4	7.9
	65	22.5	12.5	3.8	6.9
	65	20	15	4.0	7.2

60-764
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LINEAR THERMAL EXPANSION -- SODIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
56-158	Moore, H. and McMillan, P. W.	56-158	582-762	Na ₂ O - Al ₂ O ₃ - B ₂ O ₃ glasses	Not given	Annealed
51-83	Chandappa, M. and Simpson, H. E.	51-83	582-672	Na ₂ O - Al ₂ O ₃ - B ₂ O ₃ glasses	Quartz tube dilatometer	

Symbol	Material Composition						Average coefficient of	
	B ₂ O ₃		Na ₂ O		BeO		linear expansion x 10 ⁶	
	Mol %	Wt %	Mol %	Wt %	Mol %	Wt %	582-762°R	323-423°K
O	85	88.7	10	9.3	5	2.0	5.31	9.56
	75	81.3	15	14.5	10	4.2	5.44	9.80
	70	76.4	20	19.4	10	4.2	5.28	9.51
	65	71.3	25	24.4	10	4.3	5.49	9.89
	60	66.2	30	29.5	10	4.3	6.55	11.79
	55	61.1	35	34.6	10	4.3	6.32	11.37

60-755
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LINEAR THERMAL EXPANSION -- SODIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Moore, H. and McGillan, P. W.	56-154	582-762	Na ₂ O - BeO - B ₂ O ₃ glasses	Not given	Annealed

Symbol	Material Composition, %						Average coefficient of linear expansion x 10 ⁶	
	B ₂ O ₃		Na ₂ O		MgO		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	per °R	per °K
O	91.0	90	9.0	10			5.73	10.31
	89.2	85	4.7	5	6.1	10	4.12	7.41
	87.2	85	9.2	10	3.0	5	5.06	9.10
	86.2	82.5	9.3	10	4.5	7.5	4.42	7.95
	84.5	80	9.4	10	6.1	10	4.19	7.55
	81.0	75	9.6	10	9.4	15	4.14	7.45
	79.7	75	14.2	15	6.1	10	4.48	8.07
	78.9	75	16.9	18	4.2	7	4.82	8.68
	78.4	75	18.6	20	3.0	5	5.14	9.25
	77.4	70	9.8	10	12.8	20	4.09	7.37
	77.1	75	22.9	25			5.60	10.08
	74.8	70	19.0	20	6.2	10	4.93	8.88
	73.6	65	10.1	10	16.4	25	4.11	7.39
	71.0	65	19.5	20	9.5	15	5.09	9.17
	70.5	65	21.7	22.5	7.8	12.5	5.42	9.75
	69.9	65	23.9	25	6.2	10	5.81	10.45
	64.9	60	28.9	30	6.2	10	6.69	12.05
	55.6	50	30.3	30	13.1	20	6.17	11.10

60-542

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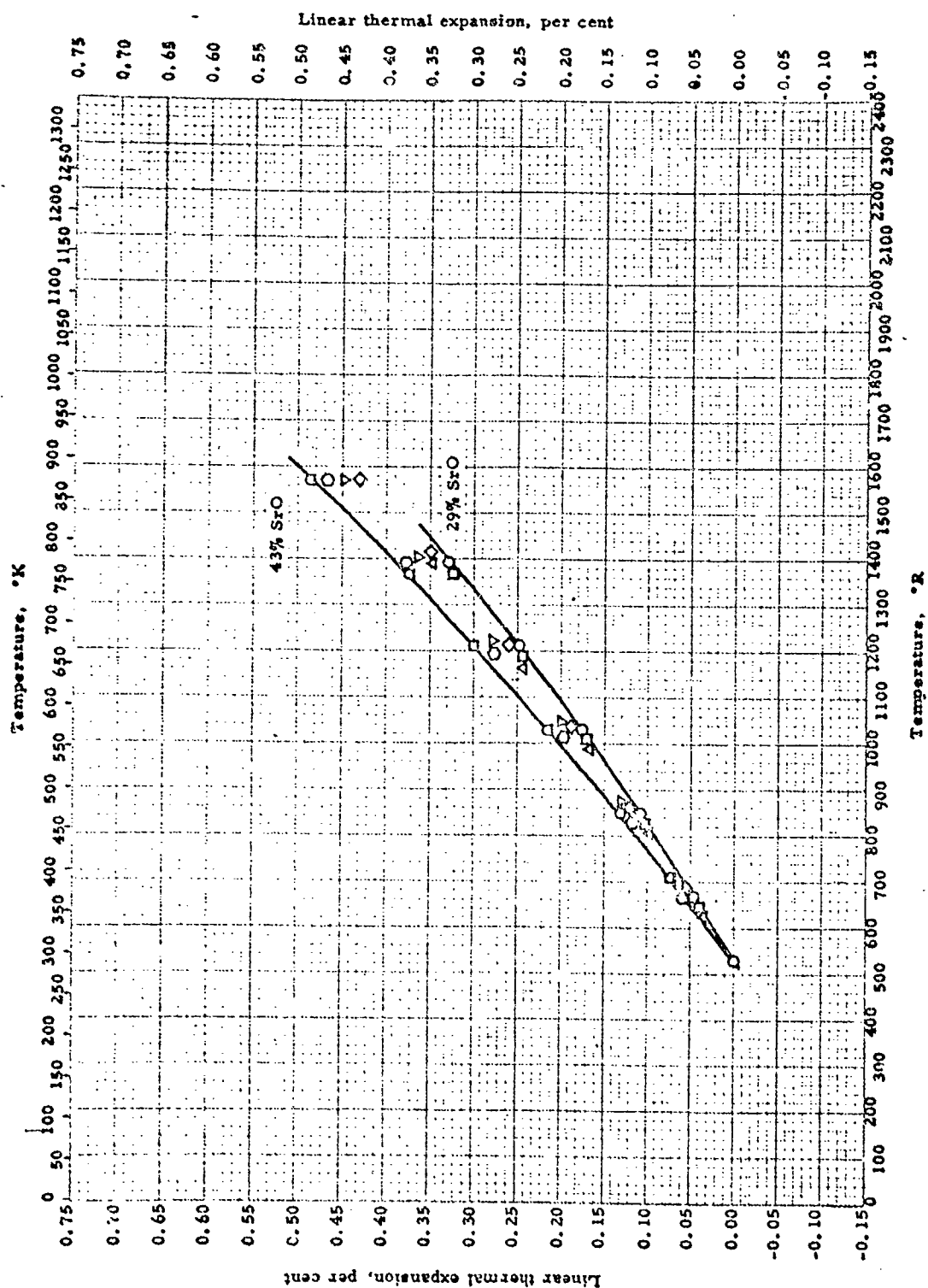
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LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Moore, H. and McMillan, P. W.	14-158	342-762	Na ₂ O - MgO - B ₂ O ₃ glasses	Not given	Annealed

60-794
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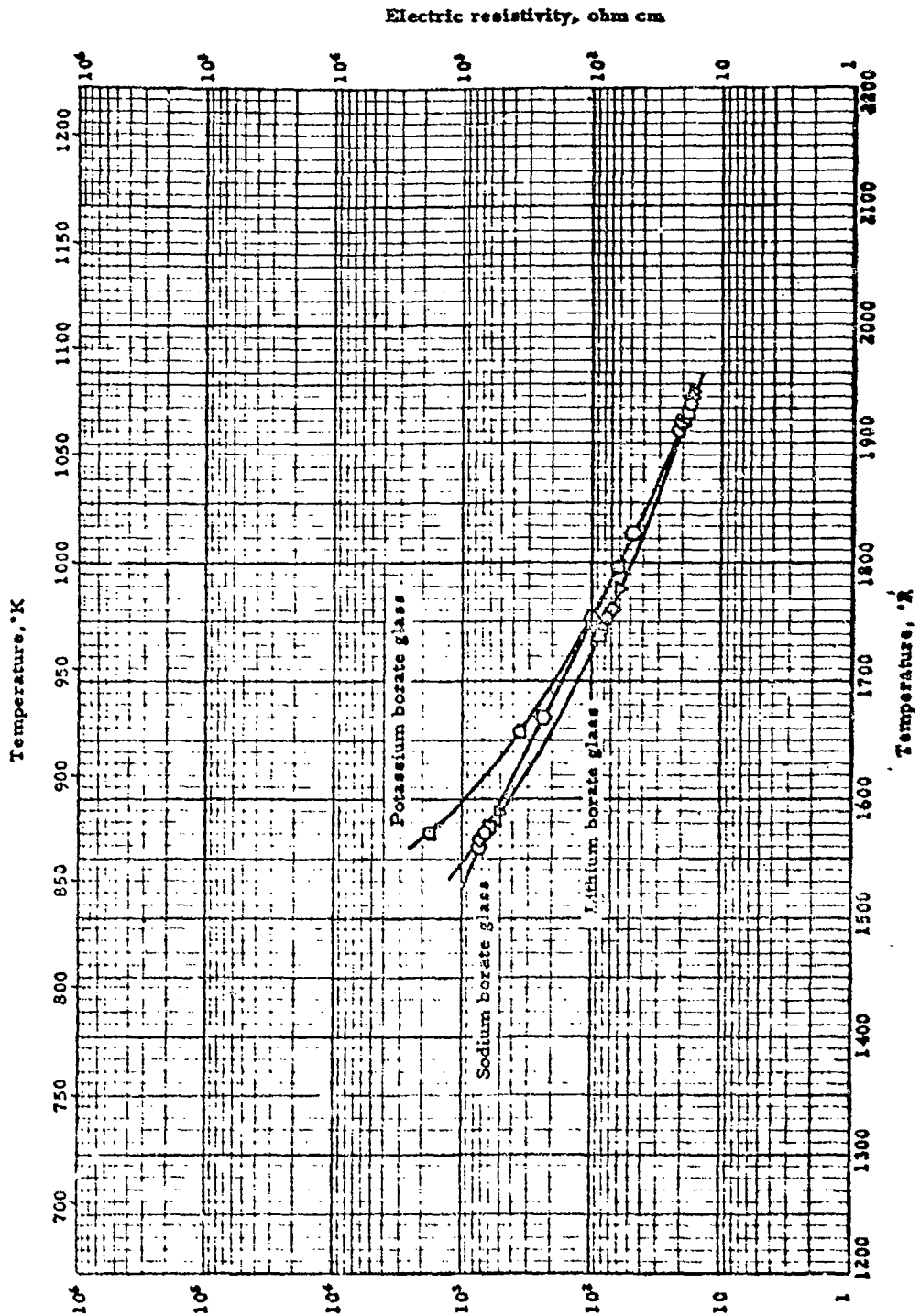


LINEAR THERMAL EXPANSION -- STRONTIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- STRONTIUM BORATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
◯ Shermer, H. F.	56-157	528-1572	71% B ₂ O ₃ ; 2% SrO	Interferometer, photographic recording 2°C/min	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr at 590°C, cooled to 500°C at 5°C/hr, furnace cooled
◻ Ibid.	56-157	528-1572	70.6% B ₂ O ₃ ; 29.4% SrO	Same as above	Same as above
△ Ibid.	56-157	528-1392	65.6% B ₂ O ₃ ; 34.4% SrO	Same as above	Same as above
◇ Ibid.	56-157	528-1572	64.5% B ₂ O ₃ ; 35.5% SrO	Same as above	Same as above
▽ Ibid.	56-157	528-1572	62.7% B ₂ O ₃ ; 37.3% SrO	Same as above	Same as above
○ Ibid.	56-157	528-1572	60.4% B ₂ O ₃ ; 39.6% SrO	Same as above	Same as above
◊ Ibid.	56-157	528-1572	57.4% B ₂ O ₃ ; 42.6% SrO	Same as above	Same as above



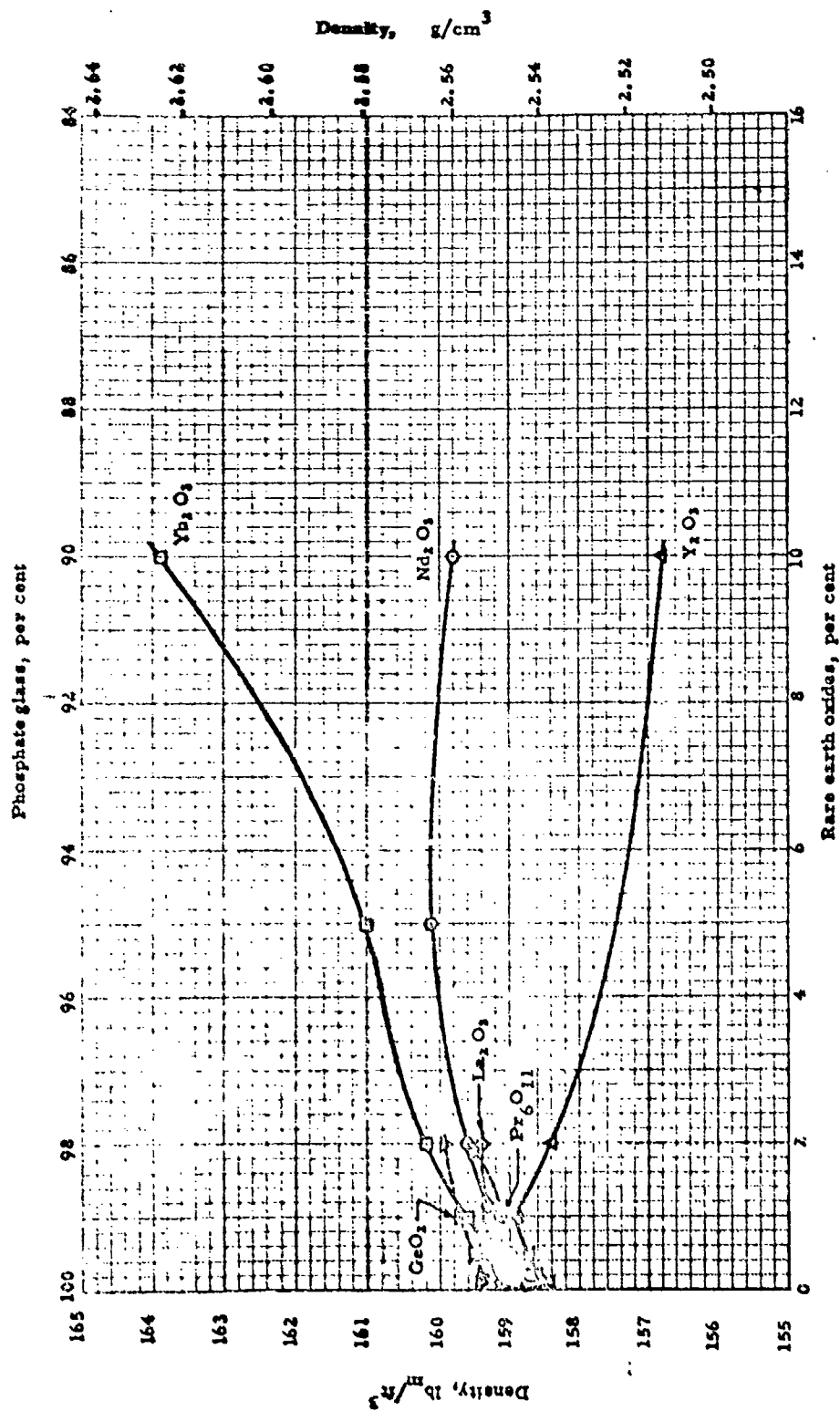
ELECTRIC RESISTIVITY -- BORATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Laurent, B.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Li ₂ O; 4.02% B ₂ O	AC impedance bridge, at 1000 cycles	
□	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Li ₂ O; 4.02% MgO	Same as above	
△	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Li ₂ O; 4.02% CaO	Same as above	
◇	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Li ₂ O; 4.02% BaO	Same as above	
▽	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Li ₂ O; 4.02% SrO	Same as above	
○	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% Na ₂ O; 4.02% B ₂ O	Same as above	
□	Ibid.	53-144	1572-1932	25.18% B ₂ O ₃ ; 10.80% K ₂ O; 4.02% B ₂ O	Same as above	

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DENSITY -- PHOSPHATE GLASS

DENSITY -- PHOSPHATE CLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vickery, R. C. and Sedlack, R.	57-187	530-537	Basic phosphate glass + Nd ₂ O ₃ · 77.6% P ₂ O ₅ ; 8.26% B ₂ O ₃ ; 5.07% CaO; 3.98% Al ₂ O ₃ ; 2.52% Fe ₂ O ₃ ; 0.91% MgO; with various % Nd ₂ O ₃	Pycnometric	Measured with CO ₂ - free water; temp. near. to 0.1°C
□	Ibid.	57-187	530-537	Basic phosphate glass + Yb ₂ O ₃	Same as above	Same as above
△	Ibid.	57-187	530-537	Basic phosphate glass + Y ₂ O ₃	Same as above	Same as above
◇	Ibid.	57-187	530-537	Basic phosphate glass + La ₂ O ₃	Same as above	Same as above
▽	Ibid.	57-187	530-537	Basic phosphate glass + Ce O ₂	Same as above	Same as above
○	Ibid.	57-187	530-537	Basic phosphate glass + Pr ₆ O ₁₁	Same as above	Same as above; auth. also report additional density data for additives of up to 2% of other rare earth oxides

Symbol	Material Composition, Mol %							Density	
	SiO ₂	B ₂ O ₃	ZnO	BaO	ZrO ₂	TiO ₂	MgO	Li ₂ O	lb _m /ft ³ g/cm ³
O	20	30	15	20	5	5	5		237 3.79
	20	30	20	25	5				245 3.93
	25	25	15	20	5	5	5		237 3.80
	30	20	15	20	5	5	5		239 3.83
	38	12	15	10	5	5	5	10	218 3.49
	38	12	15	15	5	5	5	5	214 3.43

60-760

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DENSITY -- BARIUM ZINC BOROSILICATE GLASS

DENSITY -- BARIUM ZINC BOROSILICATE GLASS

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-179	Room	Barium-Zinc-Titanium Borosilicate glasses	Weight and volume from measured dimensions	

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Symbol	Material Composition, mol, %								Density	
	SiO ₂	B ₂ O ₃	MgO	Al ₂ O ₃	CaO	Na ₂ O	ZnO	SrO	lb/in ³	g/cm ³
O	25	22.5	13.3	8.35	3.35		27.5		195	3.12
	25	22.5	13.3	8.4			30.8		197	3.15
	26.5	24	10.7	10.7		0.5	27.5		189	3.02
	40	10	20	16			6	4	174	2.79
	40	10	20	16			6	8	180	2.88
	40	10	23	17			10		177	2.83
	40	10	24	16			6	4	177	2.83
	40	10	26	14			6		169	2.71
	40	10	26	16			6	2	170	2.73
	40	10	26.6	16.7	6.7				192	3.08

60-801

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DENSITY -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	National Bureau of Standards	57-179	Room	Zinc-magnesium-aluminum bore-silicate glass	Weight and volume from measured dimensions	

Symbol	Material Composition, Mol %							Density	
	SiO ₂	B ₂ O ₃	ZnO	MgO	Li ₂ O	Al ₂ O ₃	ZrO ₂	lb m/ft ³	g/cm ³
O	10.5	36.9	31.6	10.5	10.5			196	3.14
	10	35	40	10	5			208	3.33
	10	35	40	10		5		206	3.30
	17	18	30	25	4	4	2	211	3.38
	17	18	32	25	2	4	2	213	3.41
	17	18	34	21	4	4	2	216	3.46
	17	18	34	23	2	4	2	217	3.47
	17	18	30	30		5		208	3.33
	17	18	31	30		4		211	3.38
	17	18	33	30		2		215	3.44
	17	18	36	21	4	4		214	3.43
	17	18	36	23	2	4		216	3.46

60-759

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DENSITY -- ZINC MAGNESIUM BOROSILICATE GLASS

DENSITY -- ZINC MAGNESIUM BOROSILICATE GLASS

REFERENCE INFORMATION

NBS O	Investigator National Bureau of Standards	Ref. 57-174	Range, °R Room	Material Composition Zinc-Magnesium Borosilicate Glasses	Test Method Weight and Volume from measured dimensions	Remarks

PROPERTIES OF BOROSILICATE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	157 lb _m /ft ³ *	2.52 g/cm ³ *
Annealing Point.	1491 °R*	828 °K*
Heat of Fusion		
Heat of Vaporization.		
Heat of Sublimation		

* Value for borosilicate crown glass

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	138.64	2.2208
◇	138.66	2.2310
○	157.74	2.5271
	157.25	2.5193
	157.09	2.5167
	156.74	2.5110

<u>Annealing Point:</u>	°R	°K
▽	1491	828

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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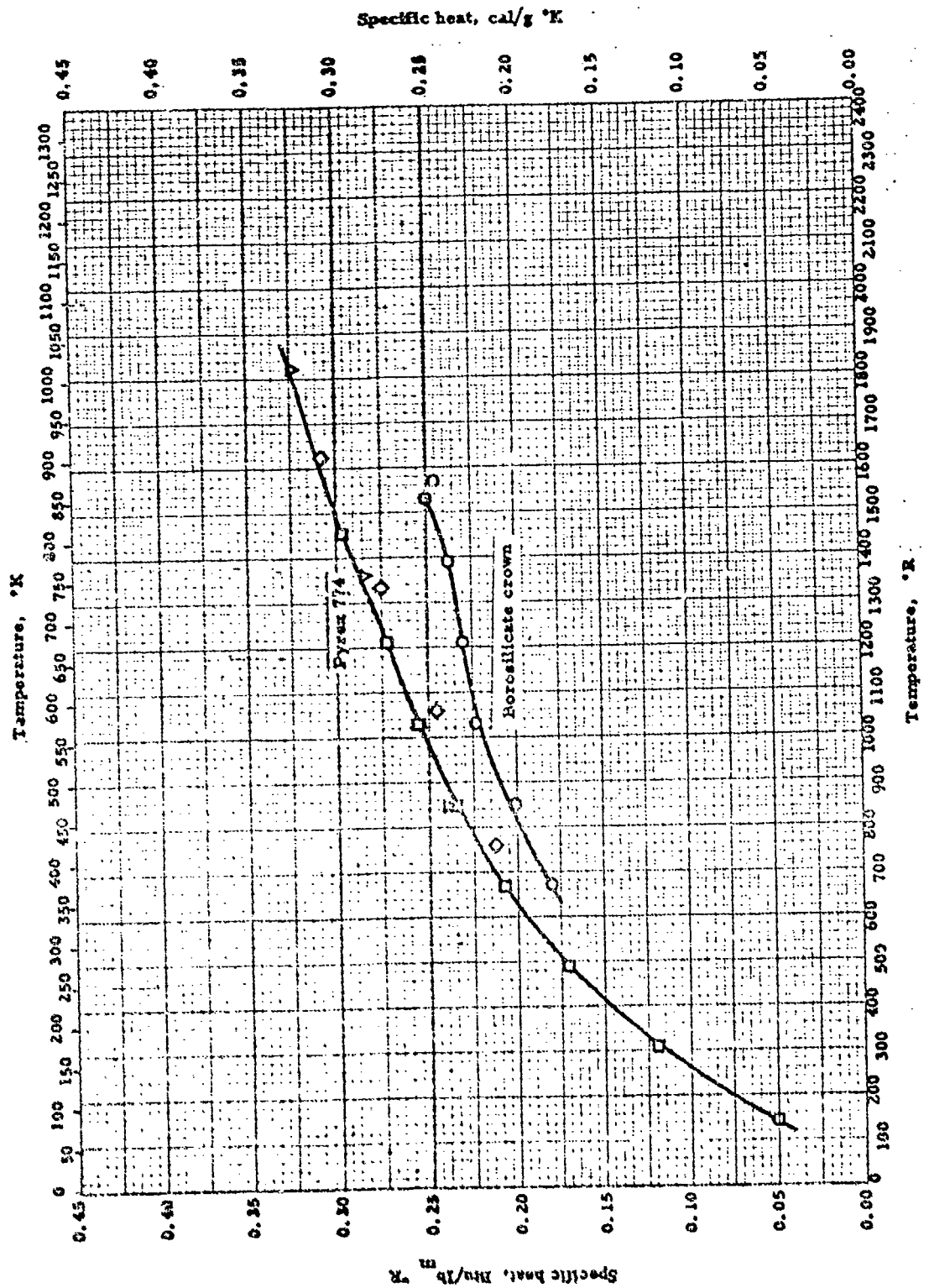
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF BOROSILICATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
Locher, C. F. and Brag, G. F.	33-35	525	Pyrex clear chemical glass No. 774	ρ : not given	Made by Cincinnati Gasket and Packing Co.
Locher, C. F., Thompson, H. B., et al.	31-35	Room	Pyrex clear chemical glass No. 774	ρ : weight in air and in water	Made by Cincinnati Gasket and Packing Co.
Naef, H. F. and Alcand, H. M.	37-104	1491	Borosilicate crown glass. Nominal: 70% SiO ₂ ; 11% B ₂ O ₃ ; 7% Na ₂ O; 3% K ₂ O	Annealing point: by thermal expansion. Quarts tube dilatometer with dial gauges with 100° C./in. rise	
Id.	37-104	Room	Same as above	ρ : computed by Newton-Drude equation $\frac{n^2-1}{\rho} = \text{const.}$ Index of refraction: Graessner V-block refractometer	4 samples



59-176
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SPECIFIC HEAT -- BOROSILICATE GLASS

SPECIFIC HEAT -- BOROSILICATE GLASS

REFERENCE INFORMATION

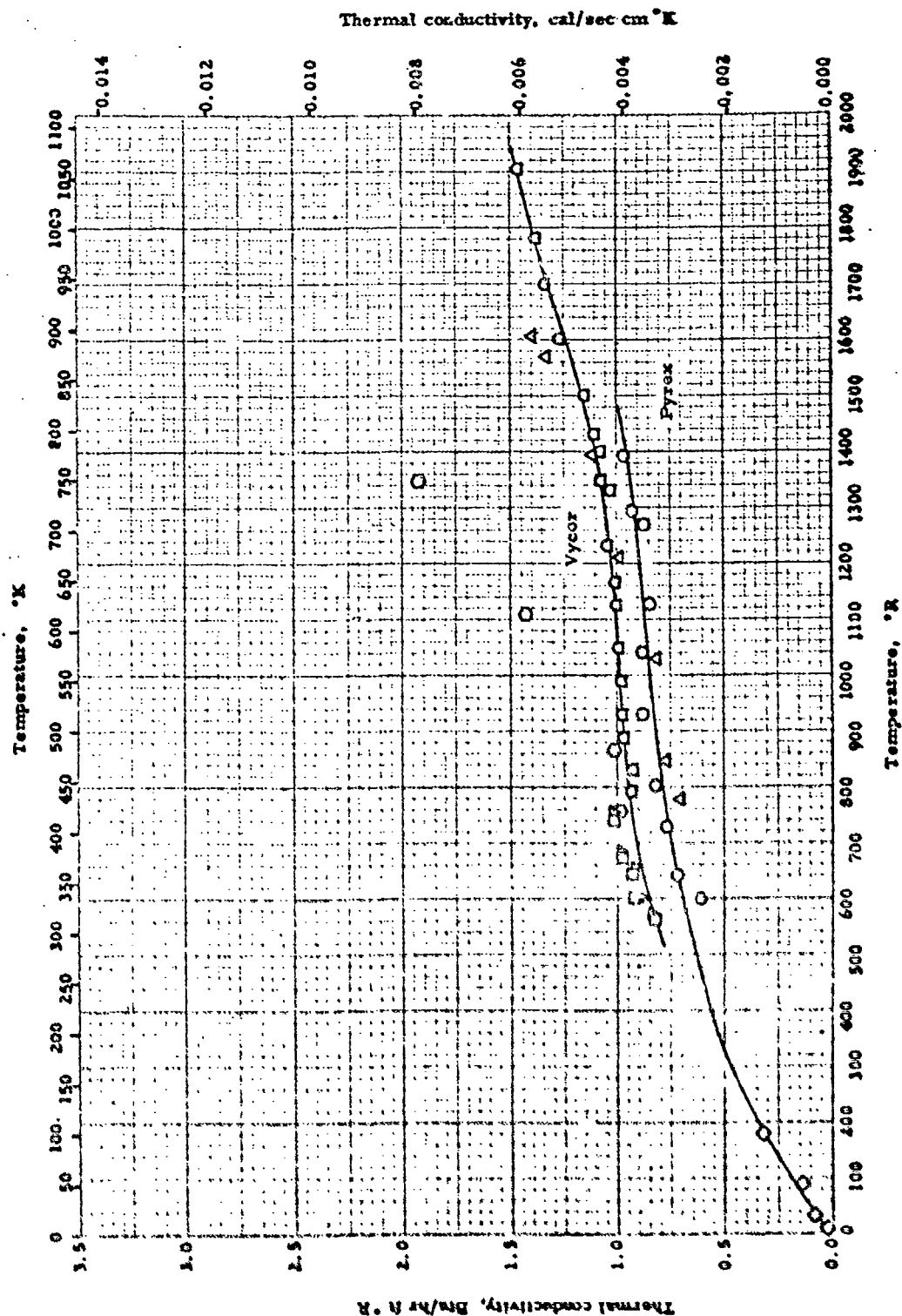
	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Prodhomme, M.	55-43	672-1572	Borosilicate crown glass	Comparative, rate of temperature rise in sample compared with standard (silica) under same conditions	Auth. b. leaves second-order transformation at 575°C
□	Lewis, C. F., Matolich, J. and Van Valter, J. A.	54-27	140-1460	Pyrex Type 774	Drop method; ice calorimeter	
◇	Kubaschewski, O. and Wistig, F. E.	41-24	532-1426	Supremax glass	Drop method	Calculated from auth's eq., avg. $c_p \left(\frac{\text{cal}}{\text{g}^\circ\text{C}} \right) = 0.1882 + 9.49 \times 10^{-5}$ $(T - 22^\circ\text{C})$, c_p calc. as $c_p = \text{avg. } c_p + \Delta T \frac{dc_p}{dT}$
▽	Kubaschewski, O.	43-13	392-1824	Supremax glass	Not described here, refers to others	Calculated from equation fitted to author's enthalpy data by least mean square routine at ARF. Auth. est. accuracy ± 1%

59-538

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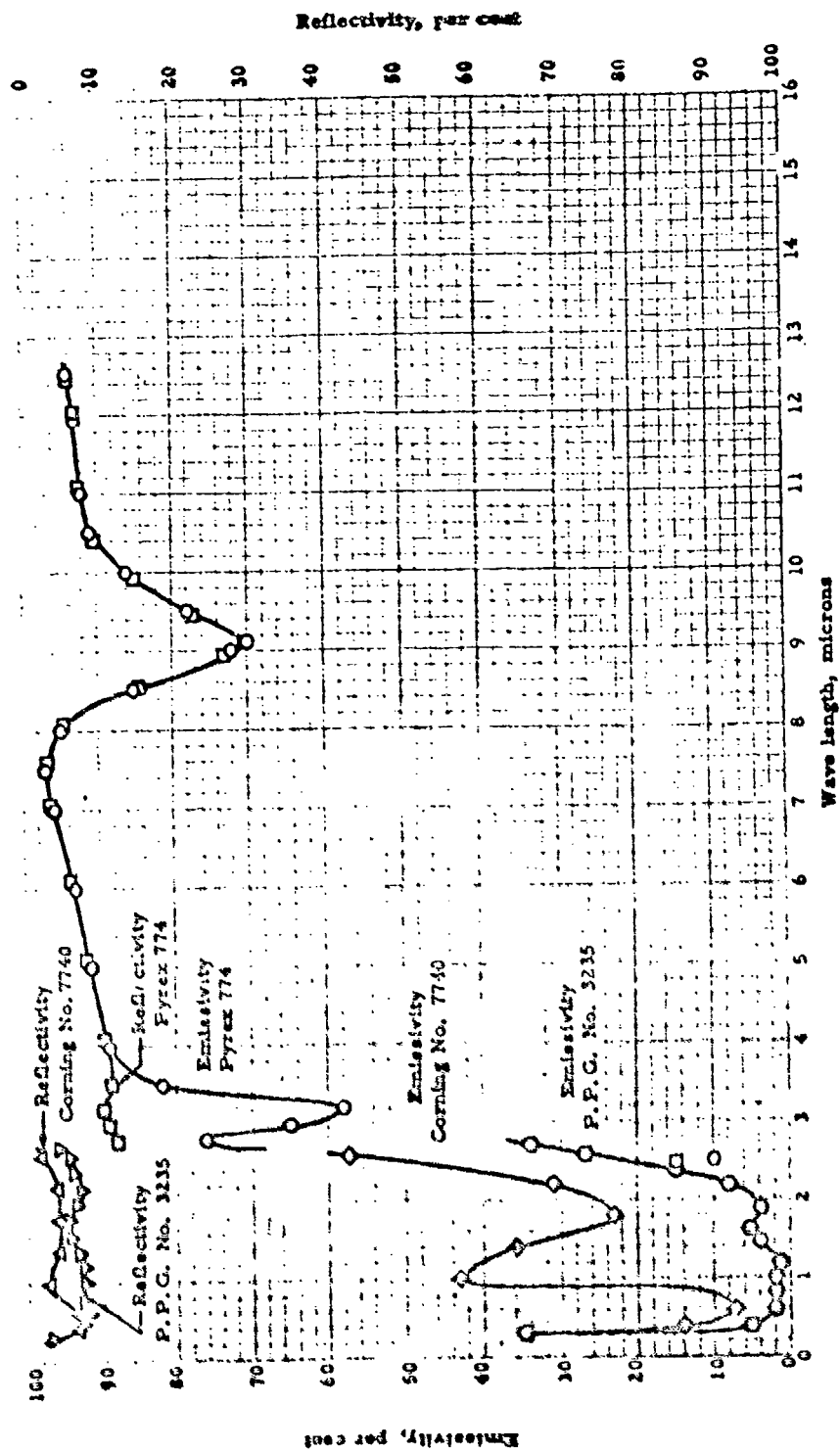


Thermal conductivity -- BOROSILICATE GLASS

THERMAL CONDUCTIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
52-33	Lucke, C. F. and Doug. G. F.	595-1333	Pyrex Glass No. 774 (clear chemical glass)	Comparative; rods (Armco Iron standard)	Tested in vacuum
53-43	Koenig, J. H., New Jersey Ceramic Research Station	560-750	Pyrex Glass. $\rho \approx 139 \text{ lb}_m/\text{ft}^3$	Comparative; rods; Cu pri- mary standard; Inconel work- ing standard	Same as above
53-43	Zaid.	570-760	Borosilicate Glass. (Arm. Cargim. Soc. standard zincs) $\rho \approx 147 \text{ lb}_m/\text{ft}^3$	Probably comparative	Same as above
54-64	Kingery, W. D. and Morison, F. H.	780-1603	Pyrex Glass	Temp. distribution in rod heated at one end	Same as above
51-14	Berman, R.	3-180	Phocair Glass (Pyrex Type)	Comparative; 1 cm cubes, Stainless steel standard	Same as above
43-11	Kearf. W. J.	700-1355	Pyrex Glass: 80.5% SiO ₂ ; 12.9% B ₂ O ₃ ; 3.8% ZnO; 2.2% Al ₂ O ₃ ; 0.4% K ₂ O	Comparative, (Armco Iron standard)	Same as above
54-27	Lucke, C. F., Matelich, J., and Van Valen, J. A.	796-1907	Vycor Glass		

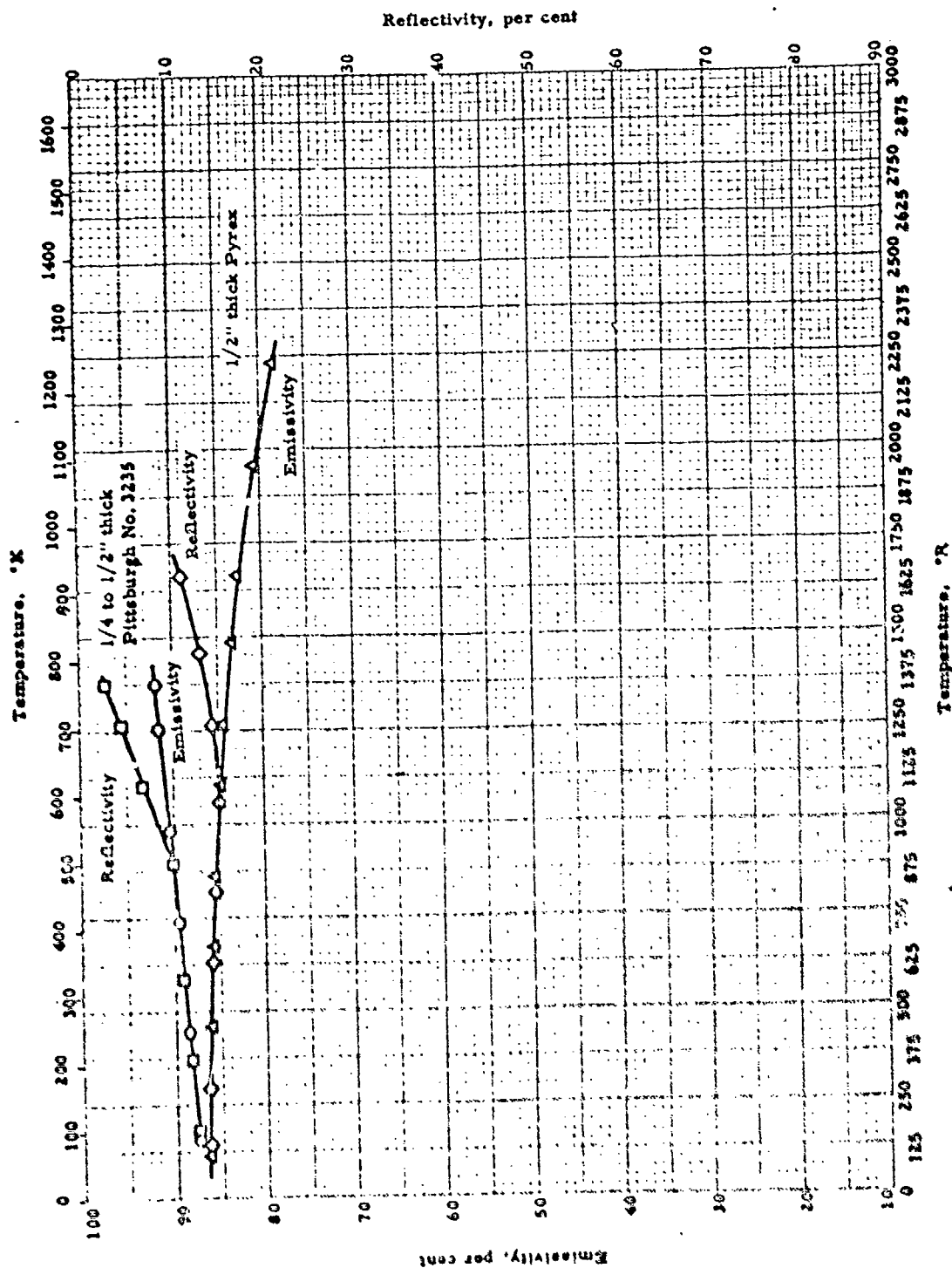


SPECTRAL EMISSIVITY -- BOROSILICATE GLASS

SPECTRAL EMISSIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	McMahon, H.	51-40	1450	Pyrex 774. 81% SiO ₂ ; 13% B ₂ O ₃ ; 3.8% Na ₂ O- K ₂ O; 2.2% R ₂ O ₃	Spectral emissivity; Parkin- Elmer spectrometer	Sample 1/8 in. thick at 1000°F
□	Ibid.	51-40	1460	Same as above	Spectral emissivity; computed from emissivity and trans- missivity. Transmission of black body radiation	Same as above. Reflectivity = 1 - transmissivity - emissivity
△	Glaza, O. H. and Morris, J. C.	59-1	Room	Glass - Corning No. 7740, Pyrex	Spectral reflectivity at 9°, same as compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	Sample 1/3 in. thick
◇	Ibid.	59-1	Room	Same as above	Spectral emissivity; meas. spectral reflectivity as above, and spectral transmissivity; comparative: radiation through sample compared with incident radiation by integrating sphere	Same as above. Emissivity = 1 - reflectivity - transmissivity
▽	Ibid.	59-1	Room	Glass - borosilicate, Pittsburgh No. 3235	Spectral reflectivity at 9°; sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	
○	Ibid.	59-1	Room	Same as above	Spectral emissivity; meas. spectral reflectivity as above, and spectral transmissivity; comparative: radiation through sample compared with incident radiation by integrating sphere	Emissivity = 1 - reflectivity - transmissivity



EMISSION -- BOROSILICATE GLASS

E) SSIVITY -- BOROSILICATE GLASS-

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Olson, O. W. and Morris, J. C.	59-1	160-1360	Pittsburgh No. 3285	Total normal emissivity: comparative: surface bright- ness compared with that of a black body hole. Sample temp. by thermocouple, accuracy = ± 3%	Sample is $\frac{1}{2}$ in. thick
Idid.	59-1	160-1360	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1-emissivity-transmissivity Auth. also report data for $\frac{1}{4}$ in. and $\frac{3}{16}$ in. thick samples, within ± 2% of values for $\frac{1}{2}$ in. thick sample.
Idid.	59-1	160-1360	Corning No. 7760, pyrex	Total normal emissivity: comparative: surface bright- ness compared with that of a black body hole	$\frac{1}{2}$ in. thick sample in air
Idid.	59-1	160-1360	Same as above	Total normal reflectivity: emissivity as above, and trans- missivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1-emissivity-transmissivity

Symbol	Material Composition, Wt %							Average coefficient of linear expansion x 10 ⁶	
	SiO ₂	B ₂ O ₃	Al ₂ O ₃	Li ₂ O	K ₂ O	CaO	Na ₂ O	°R-1	°K-1
O	49.5	20.8	9.0	10.1	10.6			5.1	9.1
	46.2	19.4	8.4	6.3	19.7			5.6	10.0
	43.4	18.2	17.9	2.9	27.8			6.0	10.8
	40.7	17.1	7.4		34.8			6.5	11.7
	50.2	14.9	18.3	10.3		6.3		4.0	7.2
	48.8	14.4	17.7	6.7		12.4		3.7	6.7
	47.5	14.0	17.2	3.4		18.0		3.4	6.1
	46.2	13.6	16.8			23.4		3.1	5.5
	51.4	21.6	9.3	10.5			7.2	5.4	9.7
	49.6	20.8	9.0	6.7			13.9	5.8	10.4
	47.9	20.8	8.7	3.2			20.2	6.1	11.0
	46.2	19.4	8.4				26.0	6.4	11.5

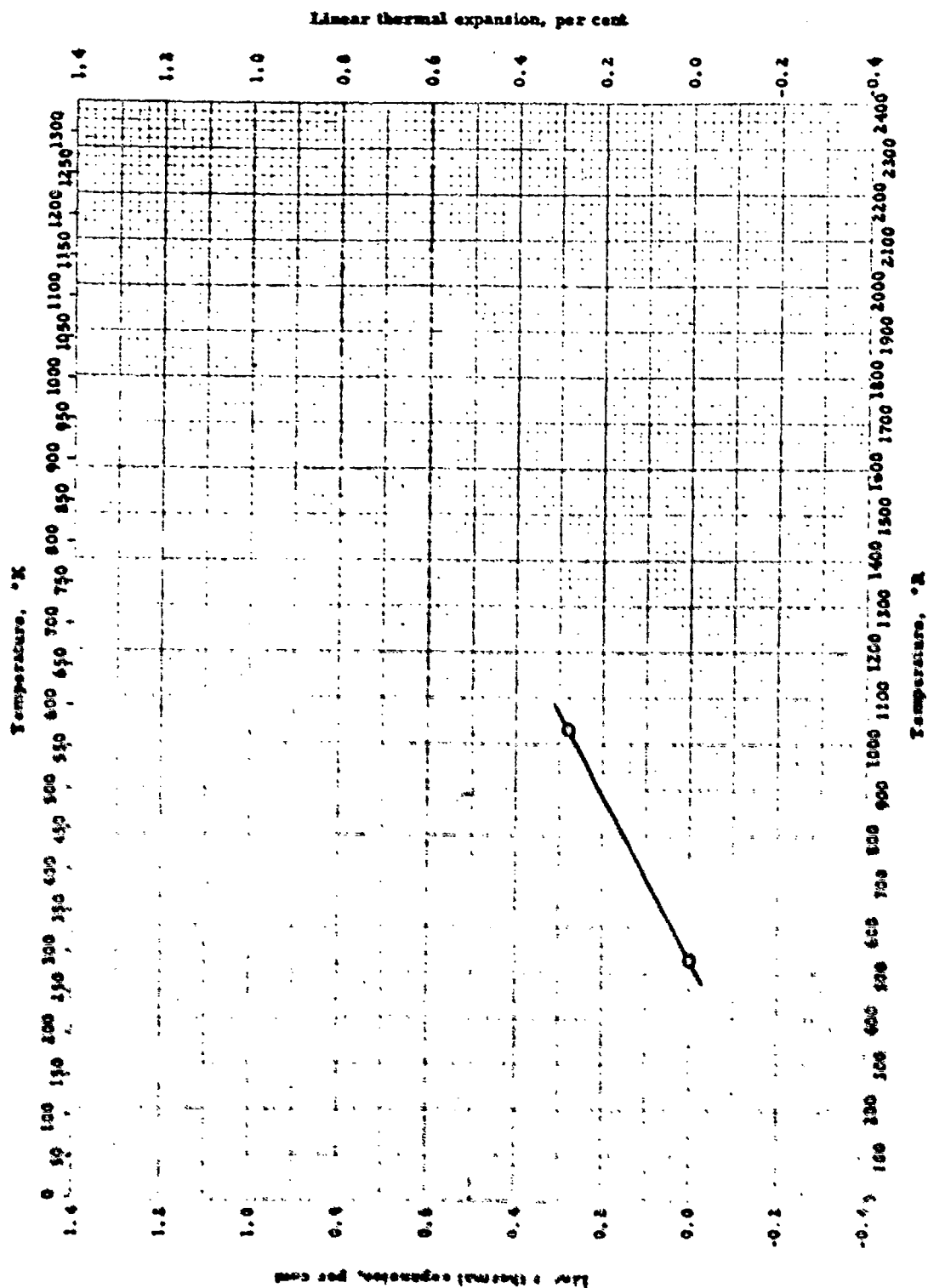
Also see graphs of $\Delta L/L$ vs T

LINEAR THERMAL EXPANSION -- ALKALI AND ALKALINE EARTH ALUMINUM
BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- ALKALI AND ALKALINE EARTH ALUMINUM
BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
0	Dale, A. E., and Pett, E. F., and Stewart, J. E.	51-61	492-1632	Series of glasses	Differential dilatometer with 10 cm x 3 mm dia. fused silica rods	

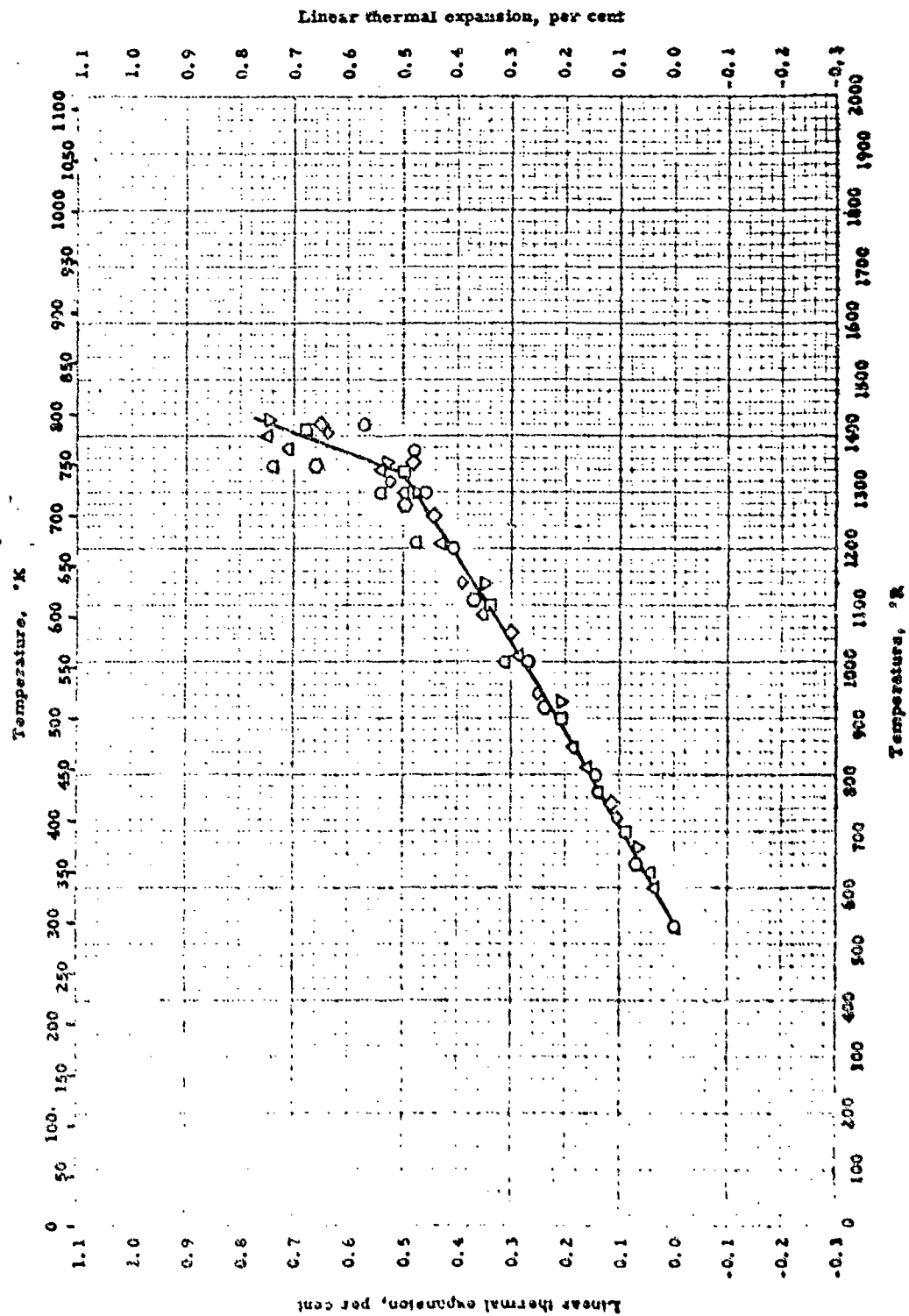


LEAD BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- LEAD BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Blechsch, F.	55-26	528-1032	78.5% PbO; 19.0% SiO ₂ ; 2.5% B ₂ O ₃ (50 mol % PbO; 45 mol % SiO ₂ ; 5 mol % B ₂ O ₃) $\rho = 181 \text{ lb/m}^3$	Not given	

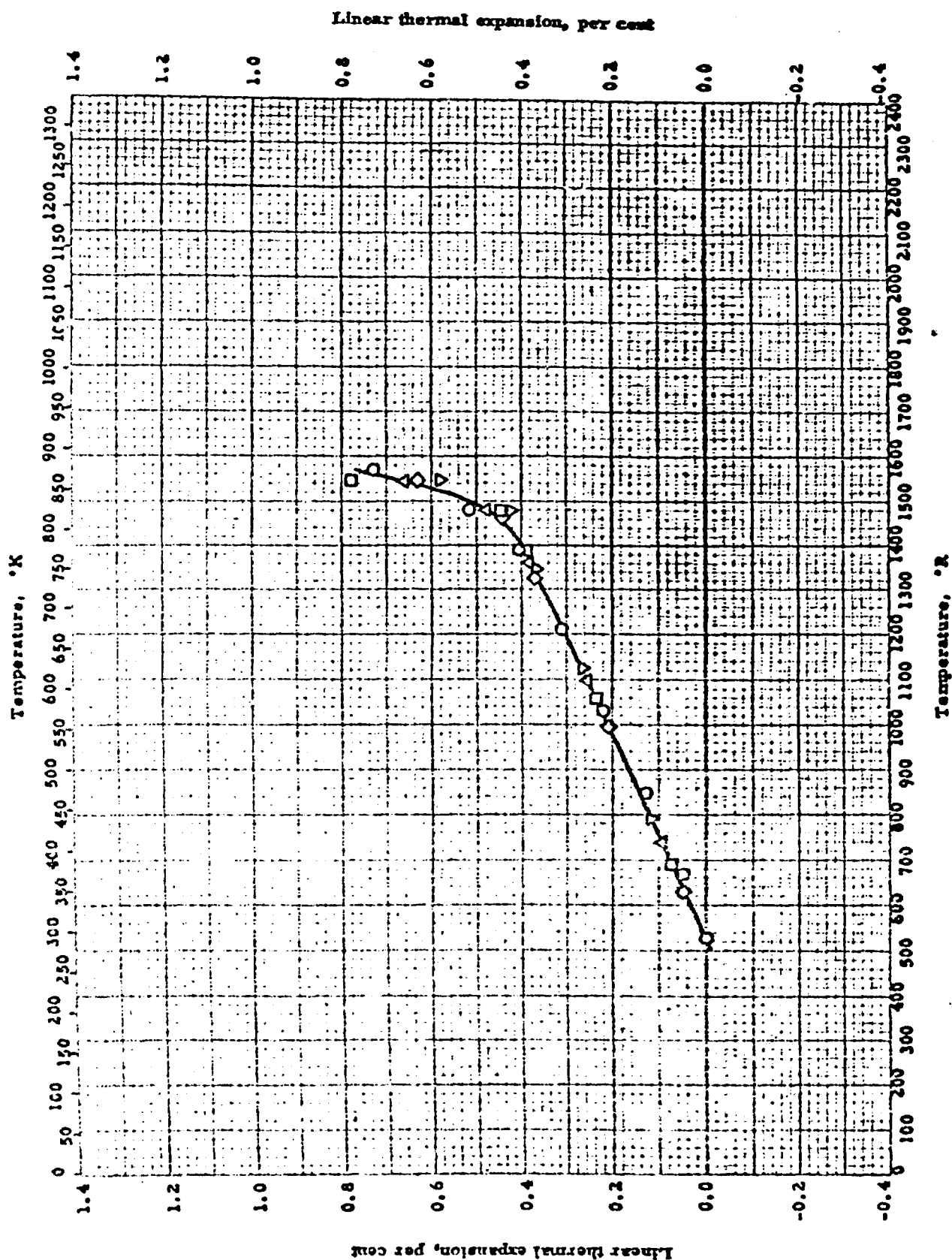


LINEAR THERMAL EXPANSION -- LITHIUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM BOROSILICATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C. H. MacKay, J. H. and T. M.	54-143	523-1420	70.37% SiO ₂ ; 16.95% Li ₂ O; 10.85% B ₂ O ₃ ; 0.40% oxides of the form R ₂ O ₃	Caetmer interferometer	Made from chemically pure materials melted and crushed 3 times, cast in 300°C mold, annealed 4 hr at 300°C, furnace cooled
D14.	54-143	523-1410	65.80% SiO ₂ ; 17.17% Li ₂ O; 15.94% B ₂ O ₃ ; 0.31% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1420	60.75% SiO ₂ ; 20.23% B ₂ O ₃ ; 17.58% Li ₂ O; 0.50% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1420	55.54% SiO ₂ ; 25.55% B ₂ O ₃ ; 17.31% Li ₂ O; 0.26% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1430	51.35% SiO ₂ ; 30.58% B ₂ O ₃ ; 17.95% Li ₂ O; 0.29% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1367	61.28% SiO ₂ ; 21.37% Li ₂ O; 16.03% B ₂ O ₃ ; 0.50% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1367	55.73% SiO ₂ ; 22.07% Li ₂ O; 20.69% B ₂ O ₃ ; 0.32% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1378	50.75% SiO ₂ ; 25.50% B ₂ O ₃ ; 21.71% Li ₂ O; 0.39% oxides of the form R ₂ O ₃	Same as above	Same as above
D14.	54-143	523-1410	65.55% SiO ₂ ; 19.51% CaO; 13.36% Li ₂ O; 1.02% B ₂ O ₃ ; 0.26% oxides of the form R ₂ O ₃	Same as above	Same as above



LINEAR THERMAL EXPANSION -- SODIUM POTASSIUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM POTASSIUM BOROSILICATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O. V. St. H. and McGraw, H. N.	57-184	523-1573	Borosilic. to Cr. in Glass. Nominal: 70% SiO ₂ , 11% B ₂ O ₃ , 9% Na ₂ O, 7% K ₂ O, 3% SO ₃	Cooling data meas. with micro- meter microscope sighting on wires suspended from sample	
D. A.	57-184	523-1545	Same as above, $p = 157.8 \text{ lb}_m/\text{in}^2$	Heating data meas. with differ- ential silica dilatometer	This sample and the following three were subjected to 4 different heat treatments which were not de- scribed
A. D. L.	57-184	523-1545	Same as above except $p = 157.2 \text{ lb}_m/\text{in}^2$	Same as above	
O. D. L.	57-184	523-1545	Same as above except $p = 157.1 \text{ lb}_m/\text{in}^2$	Same as above	
V. D. L.	57-184	523-1545	Same as above except $p = 154.6 \text{ lb}_m/\text{in}^2$	Same as above	

Symbol	Material Composition, Wt %						Average coefficient of linear expansion $\times 10^6$	
	SiO ₂	B ₂ O ₃	Na ₂ O	ZnO	Al ₂ O ₃	CaO	528-672°R	293-373°K
○	68.2	11.0	6.9	6.4	3.2	2.7	3.62	6.52
□	64.2	15.3	6.8	6.4	3.2	2.6	3.23	5.81
△	62.2				14.6	23.2	3.00	5.4
◇	60.0	19.6	6.8	6.4	3.2	2.6	3.39	6.1

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LINEAR THERMAL EXPANSION -- SODIUM ZINC BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM ZINC BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Neapolitano, A., Waxler, R. and Stuart Jr., J. M.	56-169	Room	72% SiO ₂ ; 10% B ₂ O ₃ ; 7% Na ₂ O; 5% ZnO; 3% CaO; 2% Al ₂ O ₃ ; 1% K ₂ O (mol %)	Not given	
□	Idid.	56-169	Room	68% SiO ₂ ; 14% B ₂ O ₃ ; 7% Na ₂ O; 5% ZnO; 3% CaO; 2% Al ₂ O ₃ ; 1% K ₂ O (mol %)	Not given	
△	Idid.	56-169	Room	64% SiO ₂ ; 16% B ₂ O ₃ ; 7% Na ₂ O; 5% ZnO; 3% CaO; 2% Al ₂ O ₃ ; 1% K ₂ O (mol %)	Not given	
◇	Idid.	56-169	Room	62.2% SiO ₂ ; 23.2% CaO; 14.6% Al ₂ O ₃ (weight %)	Not given	

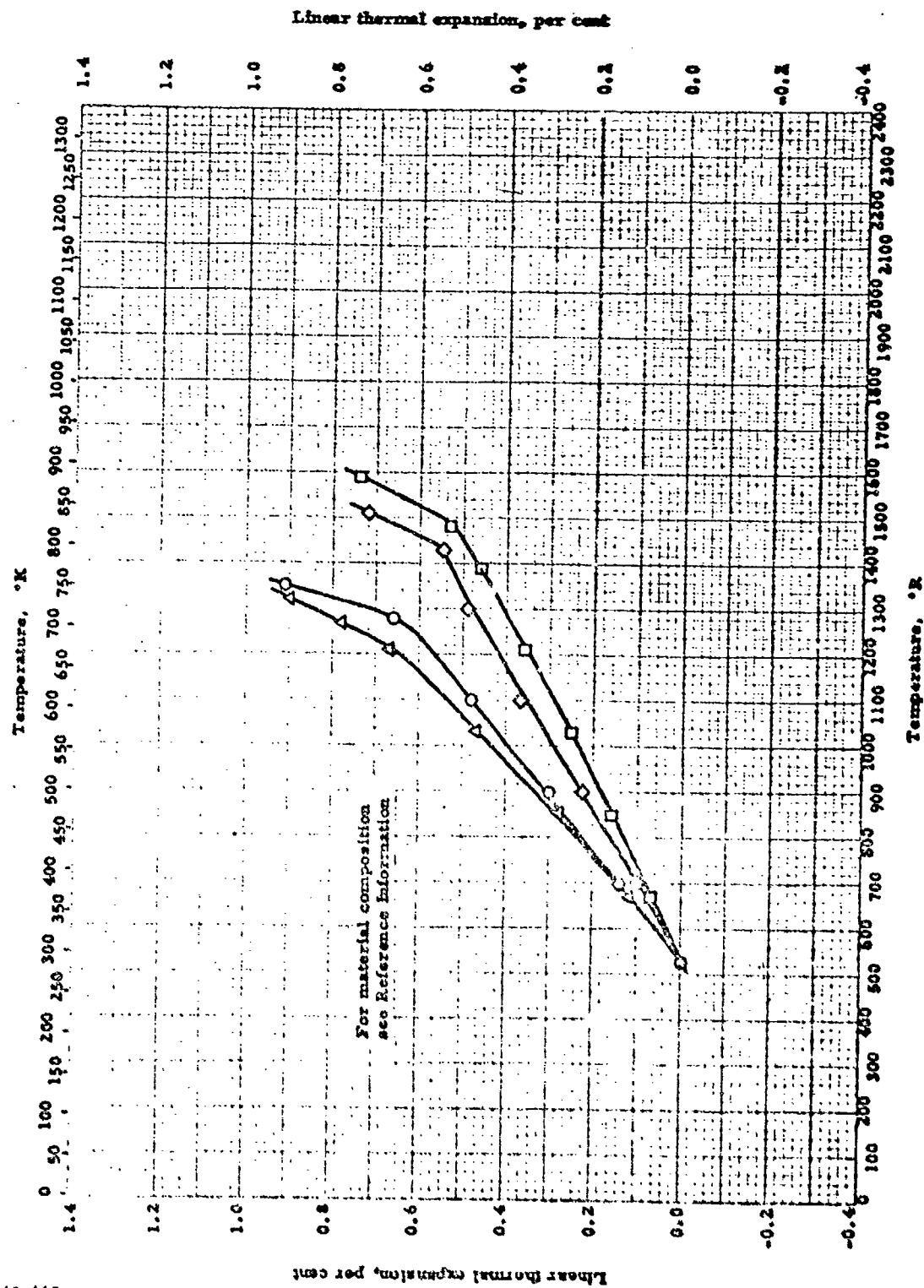
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LINEAR THERMAL EXPANSION -- SODIUM BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Huntwick, J. H. and McVay, T. N.	54-146	528-1356	57.85% SiO ₂ ; 32.32% Na ₂ O; 8.50% B ₂ O ₃ ; 0.25% metal oxides of the form R ₂ O ₃	Geertner interferometer	Made from chemically pure materials melted and crushed 3 times, cast in 300 C mold and annealed 4 hr. at 300 C, furnace cooled
□	IdA.	54-143	528-1590	71.15% SiO ₂ ; 17.28% Na ₂ O; 10.20% B ₂ O ₃ ; 0.35% metal oxides of the form R ₂ O ₃	Same as above	Same as above
△	IdA.	54-148	528-1320	51.72% SiO ₂ ; 37.40% Na ₂ O; 8.61% B ₂ O ₃ ; 0.24% metal oxides of the form R ₂ O ₃	Same as above	Same as above
◇	IdA.	54-148	528-1510	64.93% SiO ₂ ; 22.85% Na ₂ O; 10.78% B ₂ O ₃ ; 0.27% metal oxides of the form R ₂ O ₃	Same as above	Same as above

Symbol	Material Composition, Mol %						Average coefficient of linear expansion $\times 10^6$	
	SiO ₂	B ₂ O ₃	MgO	Al ₂ O ₃	ZnO	Others	672-1212°R	373-673°K
O	42.9	13	21.5	21.5		1.1% Na ₂ O	2.4	4.3
	40	10	26	14	6	4% Li ₂ O	3.3	5.9
	40	10	26.6	16.7		6.7% CaO	2.6	4.7
	40	10	20	16	6	4% ea. SrO, Li ₂ O	3.1	5.6
	40	10	23	17	10		2.6	4.6
	40	10	24	16	6	4% SrO	3.1	5.6
	40	10	20	16	6	8% SrO	3.0	5.4
	26.5	24	10.7	10.7	27.5	0.5% Na ₂ O	2.7	4.8
	25	22.5	13.3	8.35	27.5	3.35% CaO	2.8	5.1
	25	22.5	13.3	8.4	30.8		2.9	5.2
	17	18	30		35		3.4	6.2
	17	18	30	5	30		3.7	6.6
	17	18	25	4	36		3.4	6.1
	17	18	25	4	34	2% ZrO	3.5	6.3
	10.5	36.9	10.5		31.6	10.5% Li ₂ O	4.4	7.9
	10	35	10		45		3.1	5.5
	10	35	10		40		3.0	5.4

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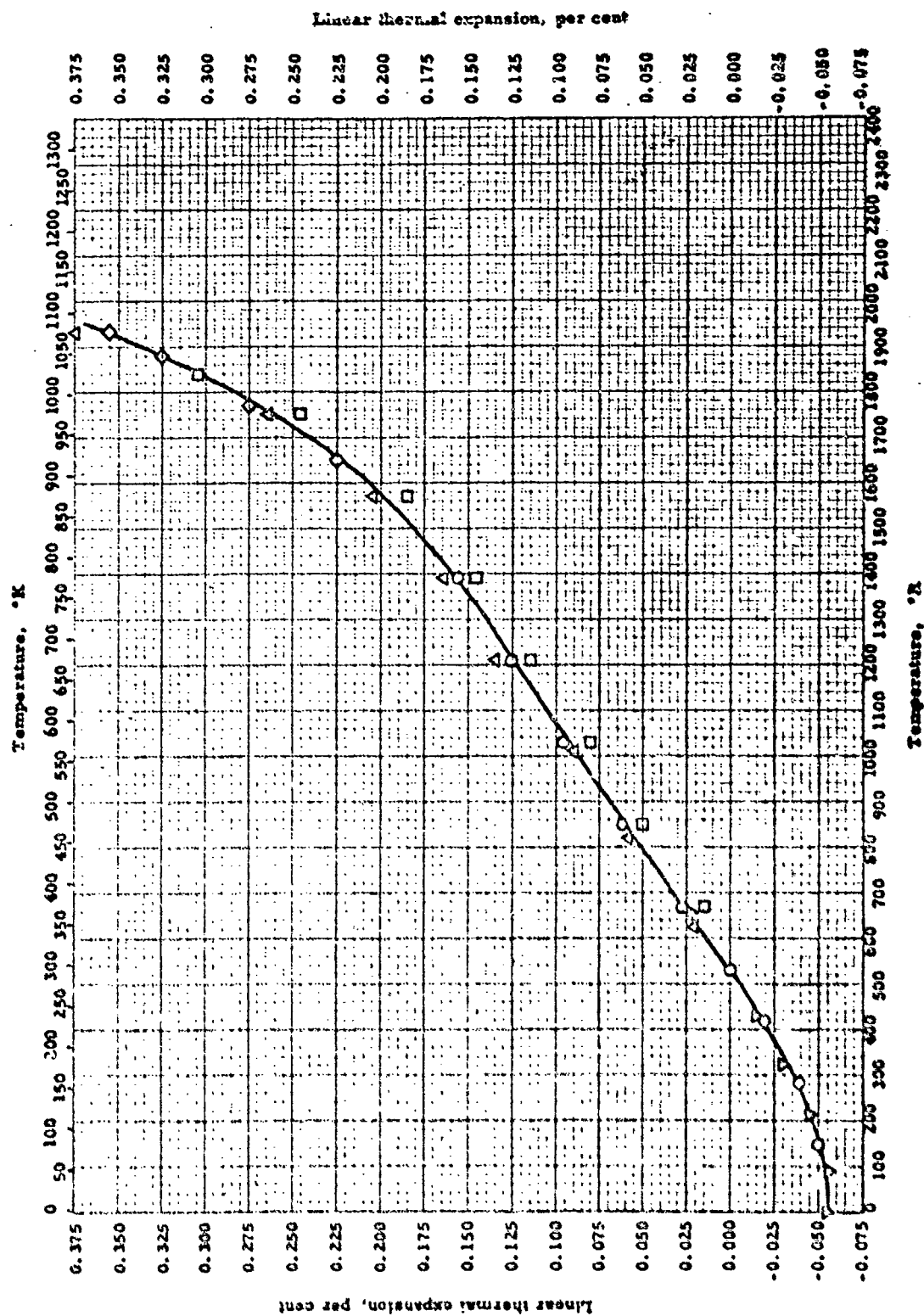
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LINEAR THERMAL EXPANSION -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-179	672-1212	Series of glasses	Not given	



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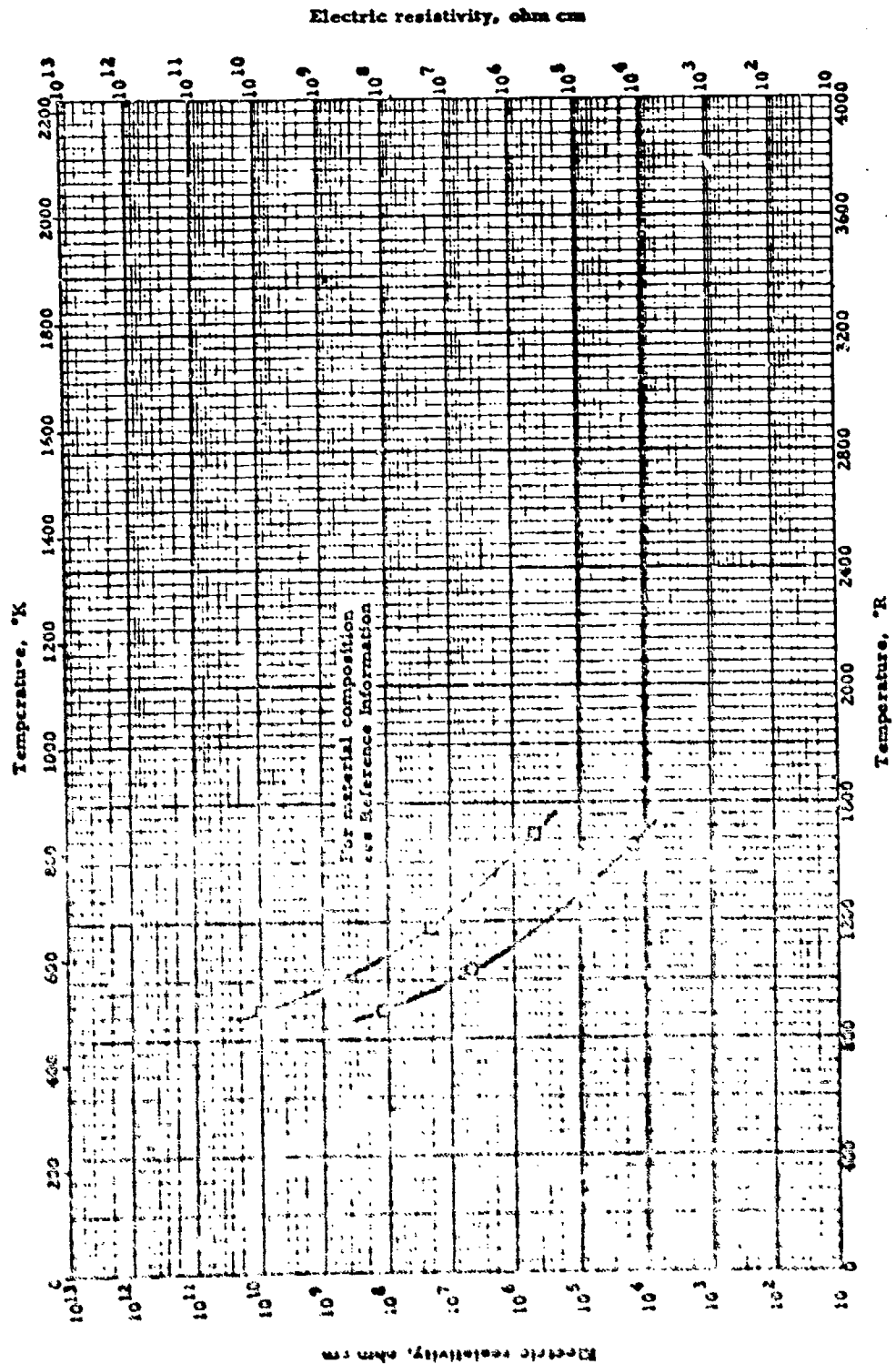
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LINEAR THERMAL EXPANSION -- BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- BOROSILICATE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
Locks, C. F., Mag. O. Z. et al.	52-33	150-1400	Pyrex Glass No. 774, clear chemical glass	Interferometer	Made by Cincinnati Gasket and Packing Co.
Cox, S. M., Carrington, J. T. and Kirtley, P. L.	51-26	580-1850	Pyrex Borosilicate Glass, 80% SiO ₂	Measured sample expansion by rotation of cylindrical sample support with other sample end held fixed. Temp. by Chromel-Alumel thermocouple	Data taken during cooling; from 750°C
R. G.	51-26	550-1930	Same as above	Same as above	Data taken during second cooling and heating
L. G.	51-26	1650-1930	Same as above	Same as above	Data taken at high temp.
Laguer, H. L.	52-39	0-650	Pyrex 774	Quartz dilatometer with dial gauges	



ELECTRIC RESISTIVITY -- BOROSILICATE GLASS

ELECTRIC RESISTIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Joynt, B.L. and Bell, W.C.	51-105	900-1464	Borosilicate glass: 18.7% SiO ₂ ; 37.3% B ₂ O ₃ ; 14.6% Na ₂ O; 7.2% TiO ₂	Wheatstone bridge	Glassy phase
Q	Did.	53-105	900-1469	24.7% SiO ₂ ; 25% TiO ₂ ; 17.4% B ₂ O ₃ ; 14.9% CaO; 7.8% Na ₂ O	Same as above	Glassy phase

PROPERTIES OF SILICA GLASS

REPORTED PROBABILE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	137.6 lb _m /ft ³	2.204 g/cm ³
Softening Point, Vycor. .	3190 °R	1770 °K
Heat of Fusion		
Heat of Vaporisation. . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	137.59	2.2040
□	137.53	2.2030
△	137.6 ± 0.06	2.204 ± 0.001
◇	137.53	2.2030
○	136.62	2.1883

<u>Softening Point:</u>	°R	°K
▽	3192	1773

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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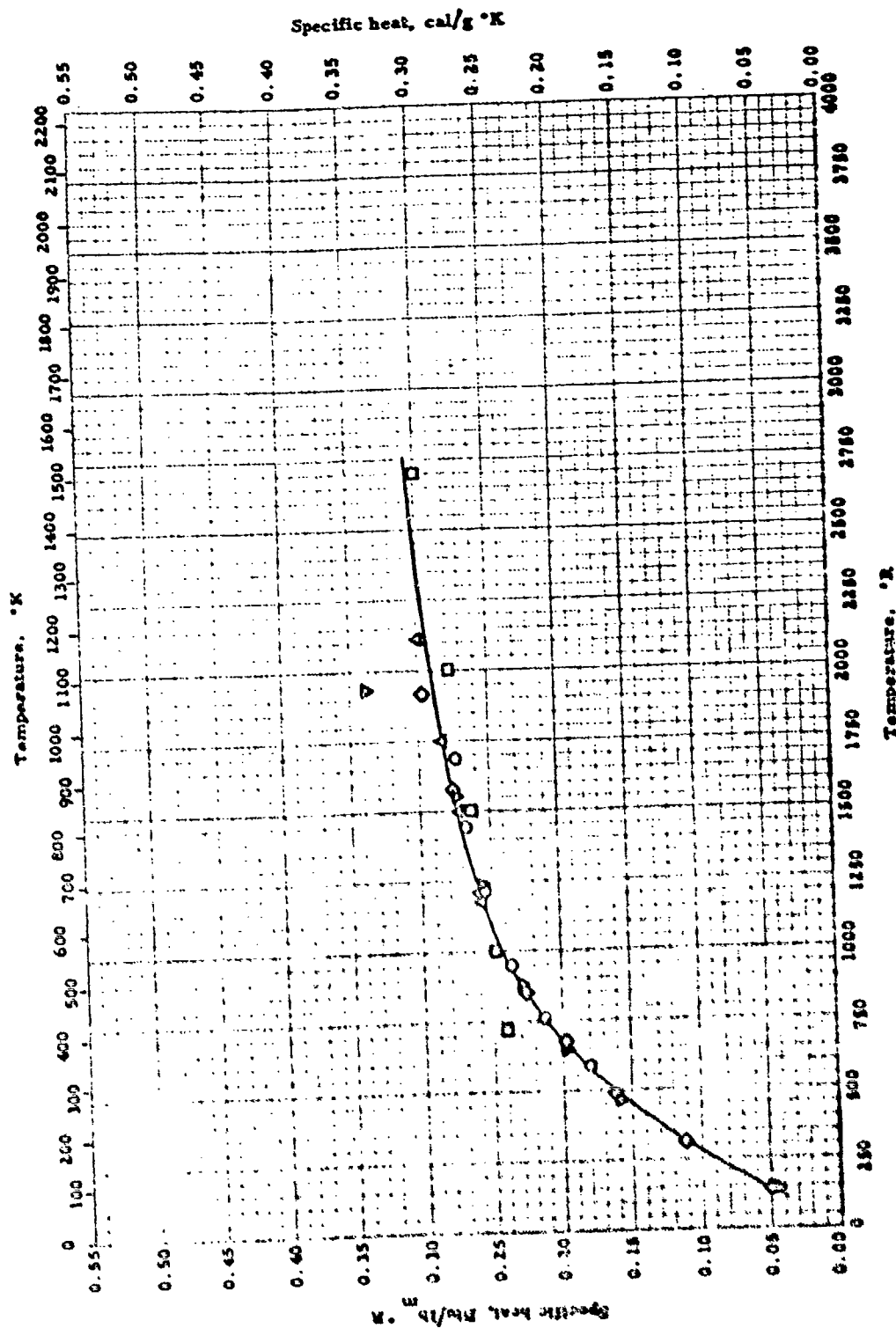
<u>Heat of Vaporisation:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF SILICA GLASS

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C Frost, D., and Kaiser, F.	32-32	Room	Not given	p: weight and volume by displacement in liquid	Auth. states accuracy $\pm 10^{-4}$ g/cm ³
C Lucka, C. F. and Sing, G. F.	52-33	528 (492-562)	Clear fused quartz	p: weight and volume by water displacement	From Hanovia Chem. Co.
A Oak Ridge National Lab.	57-150	537	Silica glass	p: weight in air and in kerosene	Measured by O. Sieman, C. D. Bopp, R. L. Towns
O Lucka, C. F., Thompson, H. B. et al.	51-65	Room	Clear fused silica	p: weight in air and in water	From Hanovia Chemical Co.
O Nordberg, M. E.	44-11	3192	Silica glass, Vycor No. 790, 96% SiO ₂ , 3% B ₂ O ₃ , 0.4% K ₂ O + 2O ₂ (chiefly Al ₂ O ₃ , traces of Na ₂ O and As ₂ O ₃)	Softening point; not described here, refers to others	Melted, formed, heat treated above annealing point separating it into two phases. The unstable glass was leached out in hot dilute acid. Then the sample was washed and dried
O Lucka, C. F. and Sing, G. F.	52-33 also 51-65	528	Vycor	p: not given	Made by Corning Glass Works

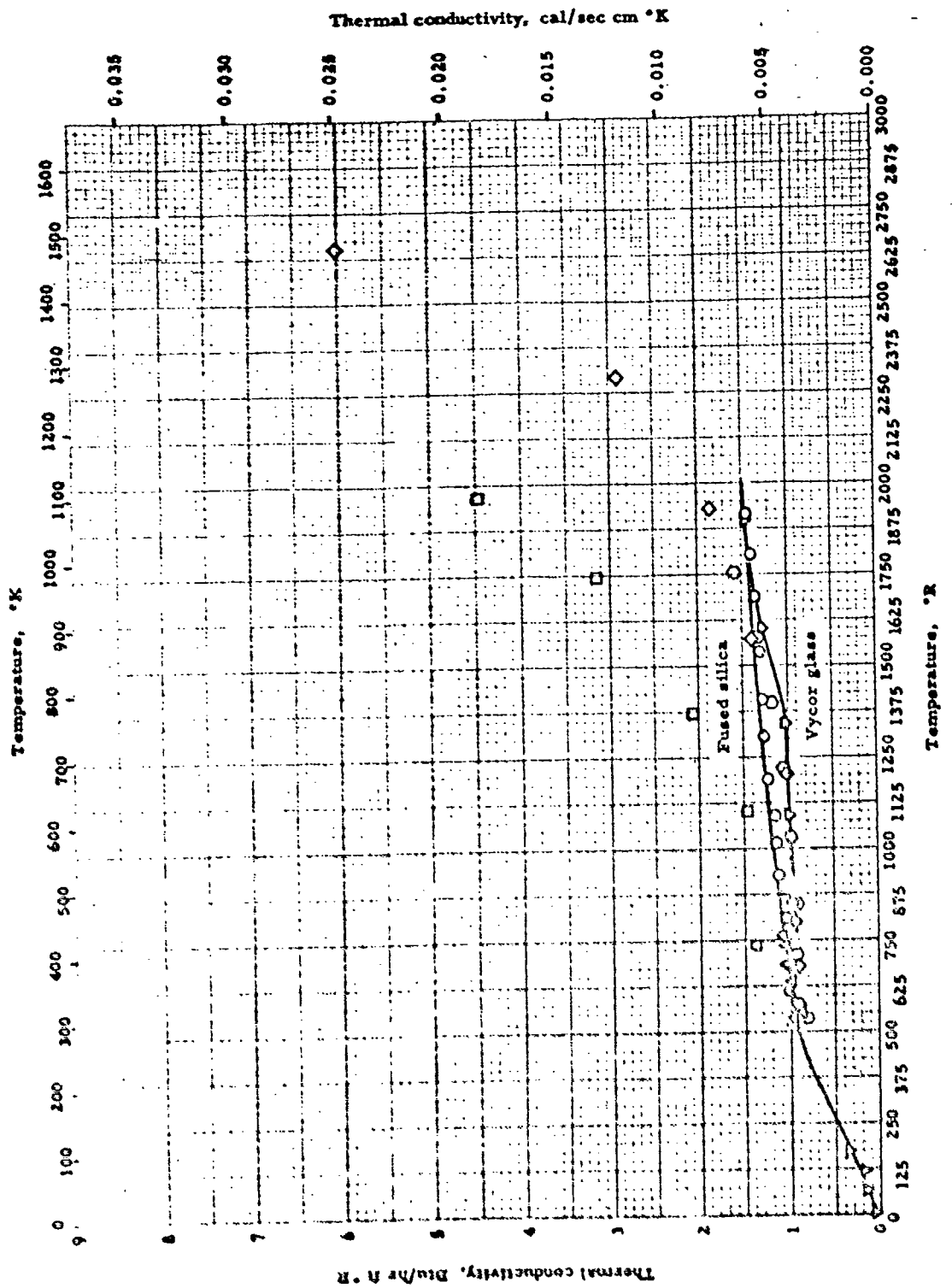


SPECIFIC HEAT -- SILICA GLASS

SPECIFIC HEAT -- SILICA GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
41-13	Moser, H.	582-1665	Quartz glass	Guarded sample	Heated in argon at low pressure
46-1	Kelley, K. K., and Taylor, B. F., and Sommers, C. H.	720-2700	Silica glass	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARJ
43-13	Kubaschewski, O.	1175-2112	Quartz glass	Drop method; copper block calorimeter	Same as above
34-27	Locke, C. F., Matolich, J., and Van Velsor, J. A.	140-1921	Clear	Drop method; ice calo- rimeter	
34-27	Idid.	140-1934	Vycor	Same as above	



Thermal conductivity -- silica glass

59-304

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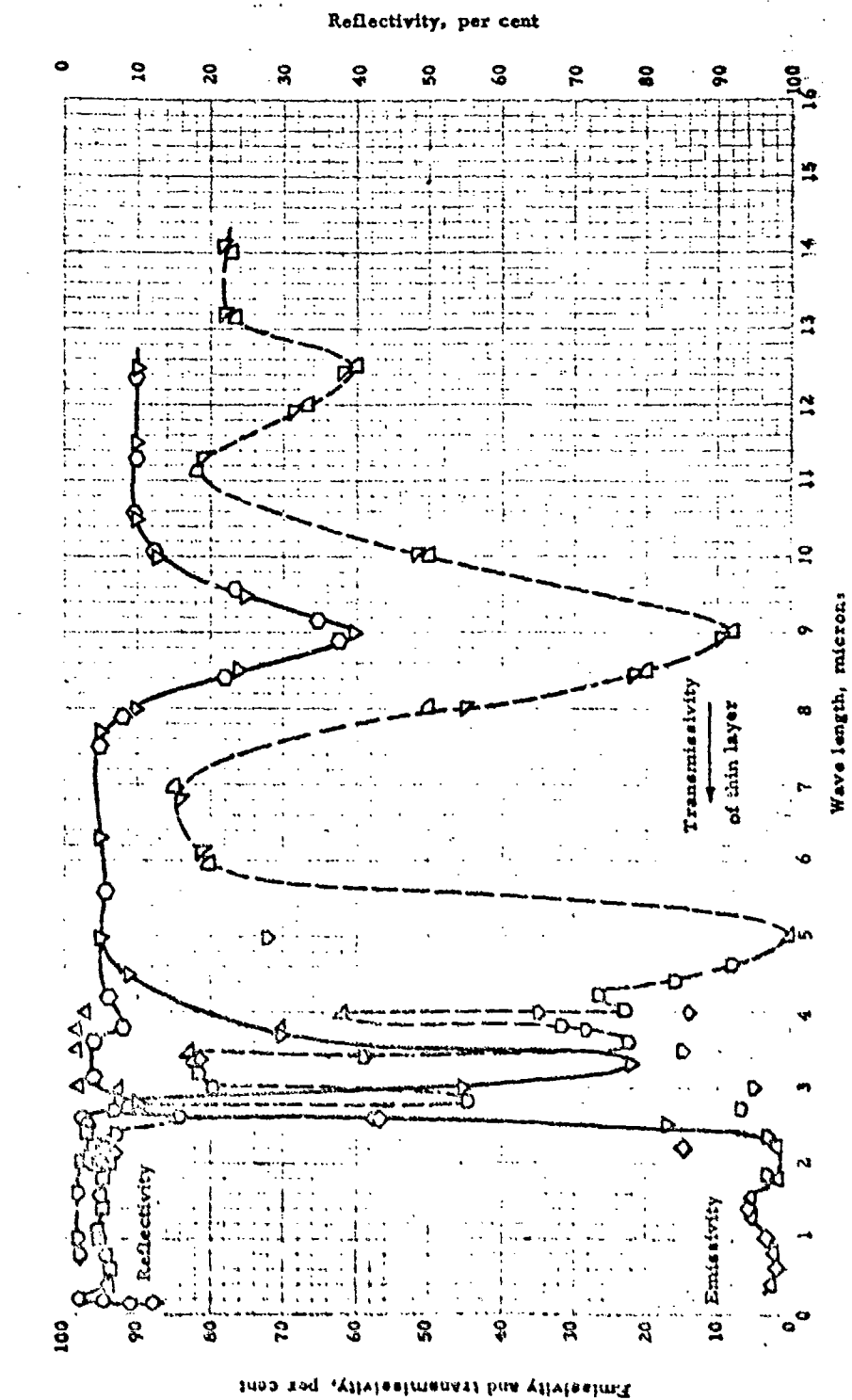
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THERMAL CONDUCTIVITY -- SILICA GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Luchs, C. F., Masolich, J. and Van Velsor, J. A.	54-27	202-1918	Fused silica (quartz)	Comparative. Armco Iron standard	Low emissivity foil on both sides of sample
○	Stapp, W. J.	43-11	680-1970	Fused silica glass (pure)	Comparative; 1 cm cubes; stainless steel standard	
△	McCombs, J. H., Coyder, N. H. et al.	53-3	560-742	Vitreous silica (silky fused silica)	Comparative; rods Cu standard	Two samples. One with silky lines parallel to heat flow, the other per- pendicular
○	Kingery, W. D. and Morton, F. H.	55-57	672-2652	Clear fused silica	Comparative; rods	
▽	Bernard, R.	51-14	6-180	Quartz glass	Temp. distribution in rod heated at one end	
○	Kingery, W. D.	55-75 also 52-68 52-137	582-1752	Fused silica (transparent)	Comparative and prolate spheroid	Samples ground from blocks of clear fused silica
○	Weeks, J. L. and Seibert, R. L.	52-1 also 51-39	623-735	Fused quartz	Temp. distribution in rod heated at one end	
○	Colosky, B. P.	52-80	560-735	Vitreous silica	Comparative; rods	2 clear samples; 1 smoky
○	Oak Ridge National Laboratory	57-150	546	Silica glass	Not described here, refers to others	
○	Luchs, C. F., Masolich, J. and Van Velsor, J. A.	54-27	796-1907	Vycor glass	Comparative. Armco Iron standard	



SPECTRAL EMISSIVITY -- SILICA GLASS

SPECTRAL EMISSIVITY -- SILICA GLASS

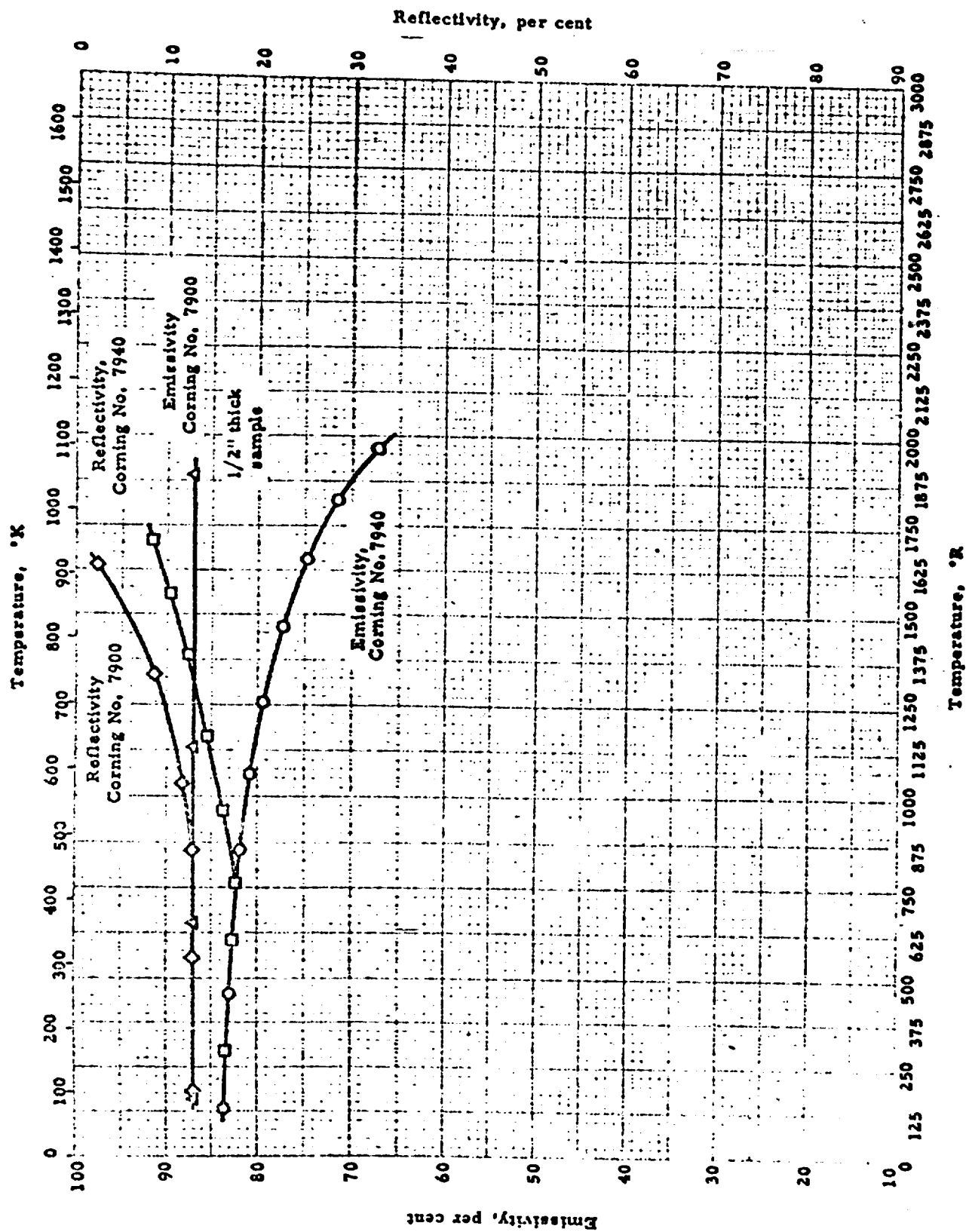
REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
41-50	Johnson, B. K.	Room	Not given	Spectral reflectivity: intensity of direct and reflected spectral lines compared on photographic plate	Polished front surface. Back surface ground
55-47	Mingery, W. D. and Norton, F. H.	537	Not given	Spectral reflectivity; not given	2mm thick sample
59-1	Cisco, O. H. and Morris, J. C.	Room	Glass - Corning No. 7940 (used silica)	Spectral reflectivity at 9°: Sample compared with MgCO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	1/2 in. thick sample
59-1	Ibid.	Room	Same as above	Spectral emissivity: spectral reflectivity means, as above, and transmissivity: comparative radiation through sample compared with incident radiation by integrating sphere	Same as above; emissivity = i-reflectivity-transmissivity
51-80	McMahon, H.	1460	Vycor glass, 96.3% SiO ₂ ; 2.9% B ₂ O ₃ ; <0.04% Na ₂ O + K ₂ O; 0.4% R ₂ O ₃	Perkin-Elmer spectrometer and thermocouple	1/16 in. thick at 1000 °F
51-80	Ibid.	1460	Same as above	Spectral reflectivity: computed from spectral emissivity and spectral transmissivity. Spectral emissivity: same as above. Spectral transmissivity: means radiation through sample from black body at sample temp.	Same as above, Reflectivity = i-transmissivity-emissivity
59-1	Cisco, O. H. and Morris, J. C.	Room	Vycor glass (Corning No. 7900) 1/2 in. thick	Spectral reflectivity at 9°: compared with MgCO ₃ std. in MgO-coated Al integrating sphere with quartz lens and PbS detector	
59-1	Ibid.	Room	Same as above	Spectral emissivity: computed from spectral reflectivity and spectral transmissivity. Spectral reflectivity: same as above. Spectral transmissivity: compared radiation thru sample with incident radiation by integrating sphere	Reflectivity = i-transmissivity-emissivity

SPECTRAL EMISSIVITY -- SILICA GLASS (Cont'd)

REFERENCE INFORMATION

Src No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Nordberg, M. E.	44-11	Room	Vycor No. 790 glass, 96% SiO ₂ ; 3% B ₂ O ₃ ; 0.4% R ₂ O ₃ + RO ₂ (chiefly Al ₂ O ₃); traces of Na ₂ O and As ₂ O ₃	Spectral transmissivity; not given	Alkali borosilicate glass, melted, formed, heat treated above annealing point, separated into 2 phases, of which the unstable was leached out in hot dilute acid, Washed and dried
Q	Kingery, W. D. and Norton, F. H.	55-47	537	Not given	Spectral transmissivity by Beckman infrared spectrometer. Data corrected for reflectivity loss	2 mm thick sample. Plotted emissivity = 1-reflectivity-transmissivity
Δ	Ibid.	55-47	537	Same as above	Same as above	Plotted transmissivity
Q	Ibid.	55-47	2652	Same as above	Same as above	Same as above
Q	Moore, H. and McMillan, F. W.	56-79	Room	100% pure SiO ₂ powder	Spectral transmissivity by Grubb-Parron infrared and ultra-violet non-recording spectrophotometer	Plotted transmissivity, thin layer of powdered sample on rock salt plates
Q	Ibid.	56-79	Room	Vitreous silica	Same as above	Same as above



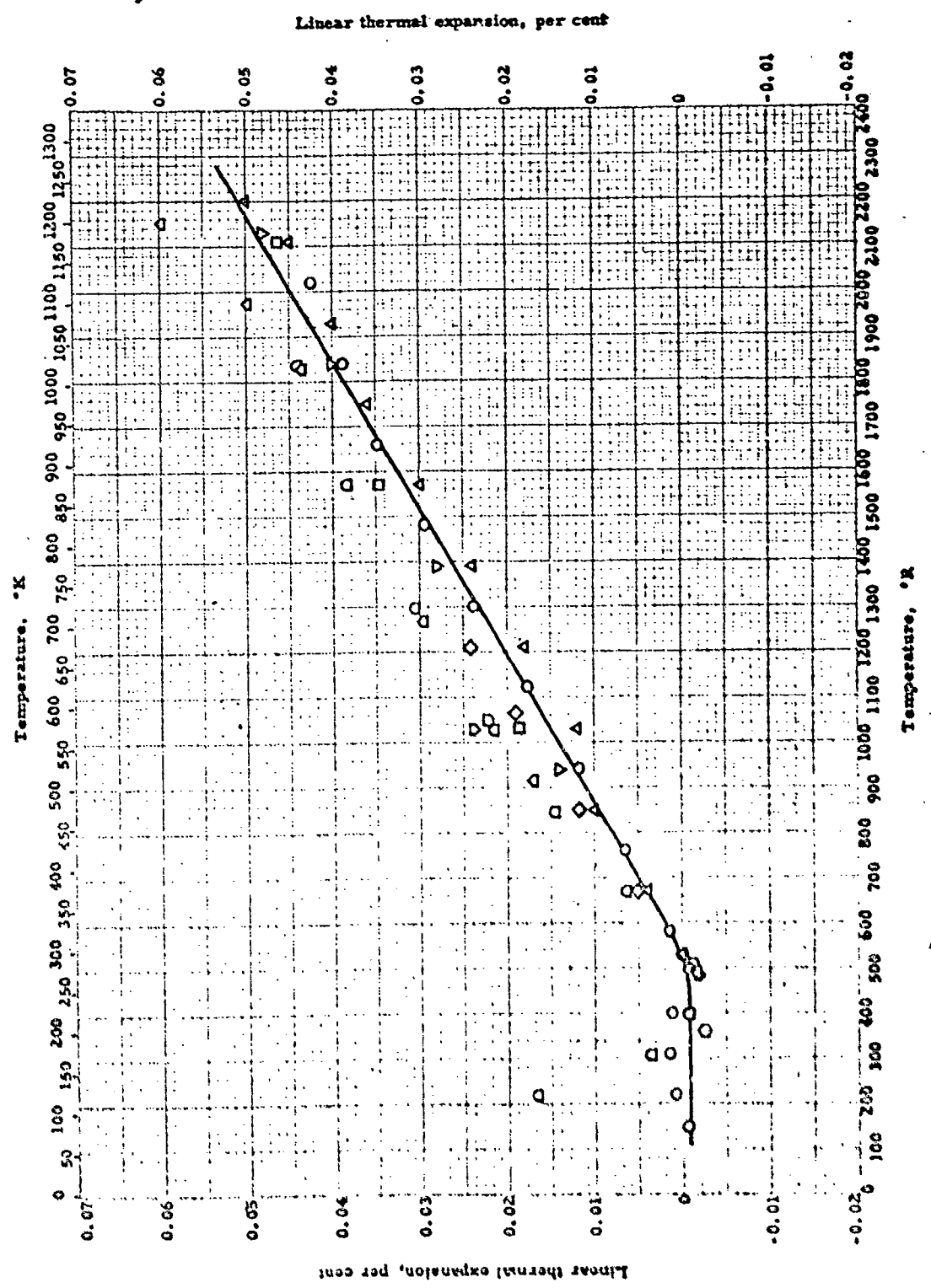
EMISSIVITY -- SILICA GLASS

EMISSIONITY -- SILICA GLASS

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	160-1960	Glass - Corning No. 7940 fused silica	Total normal emissivity: comparative: surface brightness compared with that of a black body hole, using thermopile. Sample temp. by thermocouple	1/2 in. sample in air. Accuracy $\pm 3\%$
□	Ibid.	59-1	160-1960	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1 - emissivity - transmissivity
△	Ibid.	59-1	160-1960	Glass - Corning No. 7900, Vycor	Total normal emissivity: compared: surface brightness compared with that of a black body hole	1/2 in. thick sample in air, in furnace. Data from authors' smoothed curve
◇	Ibid.	59-1	160-1960	Same as above	Total normal reflectivity: emissivity as above and transmissivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1 - transmissivity - emissivity

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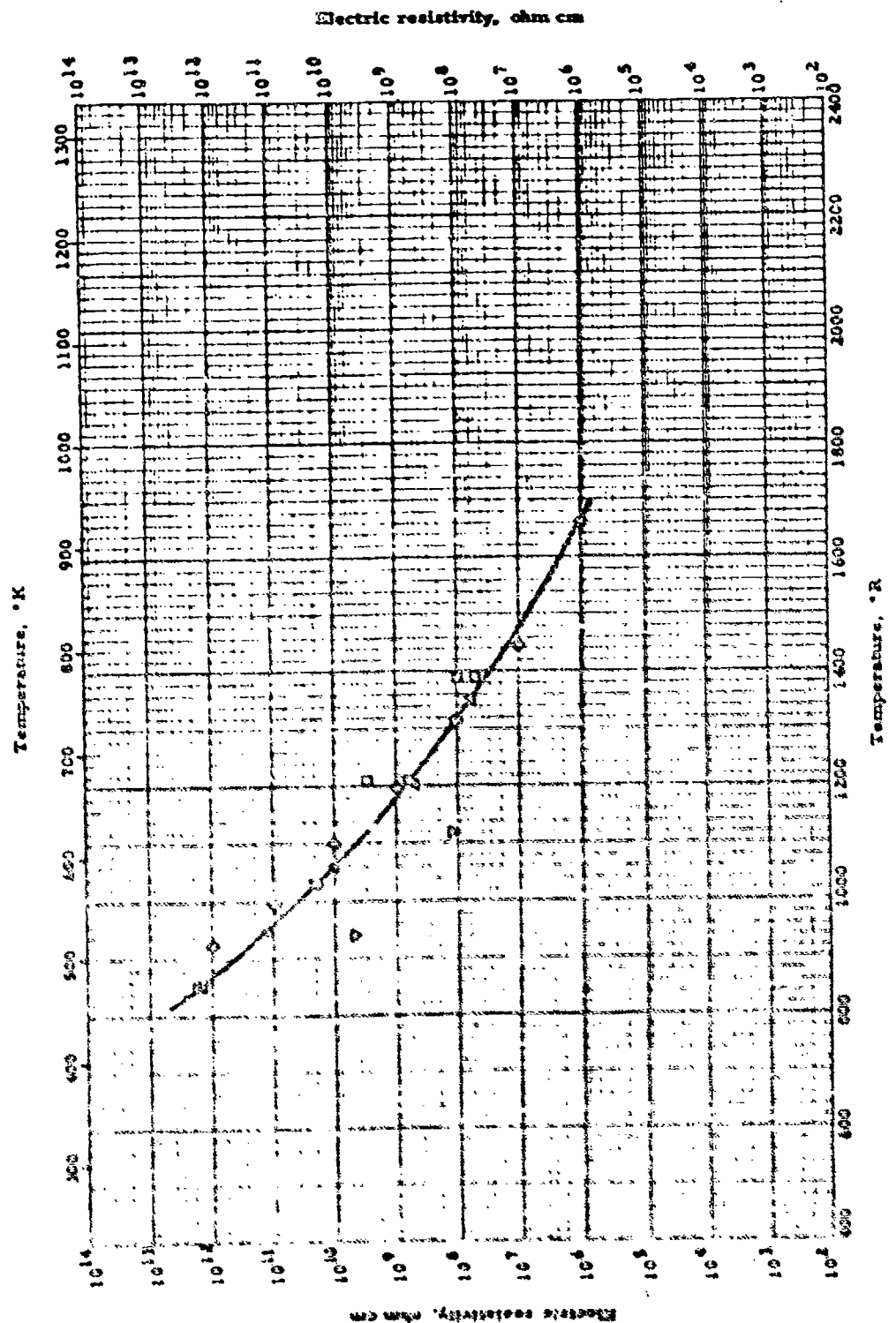


LINEAR THERMAL EXPANSION -- SILICA GLASS

LINEAR THERMAL EXPANSION -- SILICA GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Temp., °F	Material Composition	Test Method	Remarks
Q	Luchs, C. F. and Eng. G. F.	52-33	150-2072	Clear fused silica, $p = 138 \text{ lb/in}^2$	Interferometer	From Hanovia Chemical Co.
Q	Walters, O. J. and Adin, H. M.	56-7	1032-2112	Fused SiO_2	Alumina tube dilatometer, temp. by thermocouple	
A	Dubin, R. A. and Harman, C. G.	52-31	522-2202	Vitreous silica	Interferometer	
Q	Bierman, R. F.	58-464	532-1210	Fused silica, $p = 125 \text{ lb/in}^2$	Interferometer	
V	Marberg, M. E.	64-11	530-2150	Fused silica	Interferometer	
Q	Perry, S.	43-6	532-360	Fused quartz	Dilatometer with dial indicator	Auth. est; accuracy $\pm 3.4\%$
Q	Luchs, C. F., Eng. G. F. et al.	52-33	222-1842	Vycor	Interferometer	From Corning Glass Works
Q	Marshall, M. E. and Little, H. R.	66-11	822-2157	Vycor No. 750 silica glass. 95% SiO_2 ; 5% B_2O_3 ; 0.5% ZrO_2 ; + Al_2O_3 (chiefly Al_2O_3); traces Na_2O , As_2O_3	Interferometer	Melted, formed, heat treated above annealing pt. to separate it into 2 phases of which the unstable glass is leached out in hot dilute acid, washed, dried
Q	Idid.	44-11	492-1032	Same as above	Dilatometer	Same as above
Q	Idid.	66-11	492-1032	Same as above	Same as above	Pulverised vycor, refined same as above



ELECTRIC RESISTIVITY -- SILICA GLASS

ELECTRIC RESISTIVITY -- SILICA GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	53-96	252-1392	Fused quartz	Not described here, refers to others	
□	Hauth, W. E.	56-75	1032-1392	Fused silica	Bridge method; thermocouple	
△	Ericks, E. W., Moore, D. C. et al.	56-69	857-1353	Silica glass; 0.001-0.01% ea. Al, Na; 0.0001-0.01% Fe; 0.001% Mg; 0.0001-0.001% Ca; 0.0001% Cu	Potential drop, DC reversal; Fe-Constant thermocouple	Prepared from reagent grade chemicals, ground, milled, cast, annealed overnight, ground flat
◇	Russell Jr., R. and Berberich, L. J.	44-6	926-1662	Transparent fused quartz	Potential drop	Melted, formed, heat treated above the annealing point, separating into two phases. The unstable glass is leached out in hot dilute acid, washed and dried. Author reports same values for porous and nonporous types.
▽	Norberg, L. E.	44-11	942-1122	Vycor No. 790 silica glass. 96% SiO ₂ ; 3% B ₂ O ₃ ; 0.4% R ₂ O ₃ + R ₂ O ₂ (chiefly Al ₂ O ₃); traces of Na ₂ O and As ₂ O ₃	Wheatstone bridge	

Symbol	Density		Melting Point	
	lb in	g/cm ³	°R	°K
○	227	3.63	1428	793
□	208	3.33	1428	793
△	190	3.04	1442	801
◇	176	2.82	1410	783
▽	217	3.48	1450	805
○	235	3.76	1554	863

PROPERTIES OF FLUOBORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wasserman, T. and Tetrah. R.	52-115	Room 1428-1554	70% BaF ₂ ; 10% B ₂ O ₃	p: not given MP: not given	B ₂ O ₃ prepared by dehydrating H ₂ BO ₃ at 200-300°C. Chemically pure BaF ₂ . Material melted in alumina crucible at 1100°C
□	Did.	52-115	Room 1428-1554	60% BaF ₂ ; 40% B ₂ O ₃	p: same as above MP: same as above	Same as above
△	Did.	52-115	Room 1428-1554	50% BaF ₂ ; 50% B ₂ O ₃	p: same as above MP: same as above	Same as above
◇	Did.	52-115	Room 1428-1554	40% B ₂ O ₃ ; 40% BaF ₂	p: same as above MP: same as above	Same as above
▽	Did.	52-115	Room 1428-1554	40% B ₂ O ₃ ; 40% BaF ₂ ; 20% B ₂ O	p: same as above MP: same as above	Same as above
○	Did.	52-115	Room 1428-1554	40% B ₂ O; 40% B ₂ O ₃	p: same as above MP: same as above	Same as above

PROPERTIES OF GERMANIUM OXIDE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	229 lb _m /ft ³ *	3.67 g/cm ³ *
Melting Point.		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Average for engineering purposes

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	230	3.68
□	229	3.67
△	228	3.66
◇	228	3.65
▽	227	3.64

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
------------------------------	---------------------	-------

<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF GERMANIUM OXIDE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
Q	Parish, N. M. and Simpson, H. E.	52-143	Room	79.4% GeO ₂ ; 14.1% Na ₂ O; 6.5% CaO	p: weight and volume by displacement in liquid	
Q	Ibid.	52-143	Room	79.35% GeO ₂ ; 15.4% Na ₂ O; 5.35% CaO	p: same as above	
Δ	Ibid.	52-143	Room	79.3% GeO ₂ ; 16.6% Na ₂ O; 4.28% CaO	p: same as above	
◇	Ibid.	52-143	Room	79.2% GeO ₂ ; 17.75% Na ₂ O; 3.25% CaO	p: same as above	
▽	Ibid.	52-143	Room	79.0% GeO ₂ ; 18.9% Na ₂ O; 2.15% CaO	p: same as above	

Symbol	Nominal Composition, %			Density	
	TeO ₂	MoO ₃	WO ₃	lb _m /ft ³	g/cm ³
O	69	31	---	314	5.03
□	83.3	--	16.7	363	5.84
	82.3	--	17.7	366	5.86
	79.1	--	20.9	368	5.90
	77.5	--	22.5	370	5.92
	75.6	--	24.4	371	5.94
	65.5	--	34.5	379	6.07

60-538

WADC TR 58-476

911

VII - C

DENSITY -- TELLURIUM OXIDE GLASS

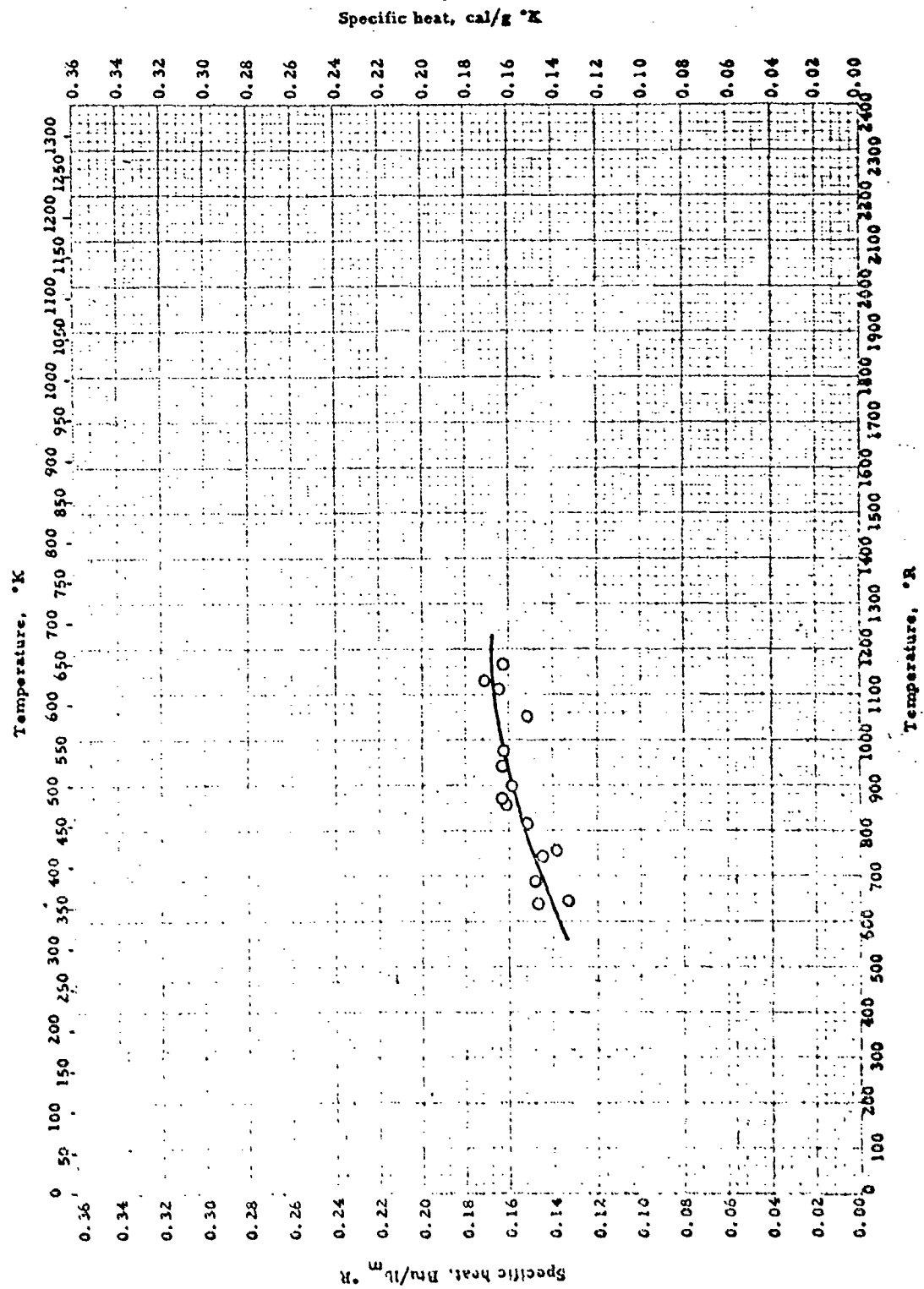
DENSITY -- TELLURIUM OXIDE GLASS

REFERENCE INFORMATION

Investigator	Ref.	Temp., °R	Material Composition	Test Method	Remarks
Deitz, A. E., Peggs, E. F., and Stanworth, J. Z.	54-140	Room	TeO ₂ + MoO ₃ glass 69% TeO ₂ ; 31% MoO ₃	Not given	Melted in Al ₂ O ₃ crucible
Id.	54-140	Room	TeO ₂ + WO ₃ glasses	Same as above	Same as above

D

60-730
WADC TR 58-476 913



SPECIFIC HEAT -- GERMANIUM OXIDE GLASS

VU - C

SPECIFIC HEAT -- GERMANIUM OXIDE GLASS

REFERENCE INFORMATION

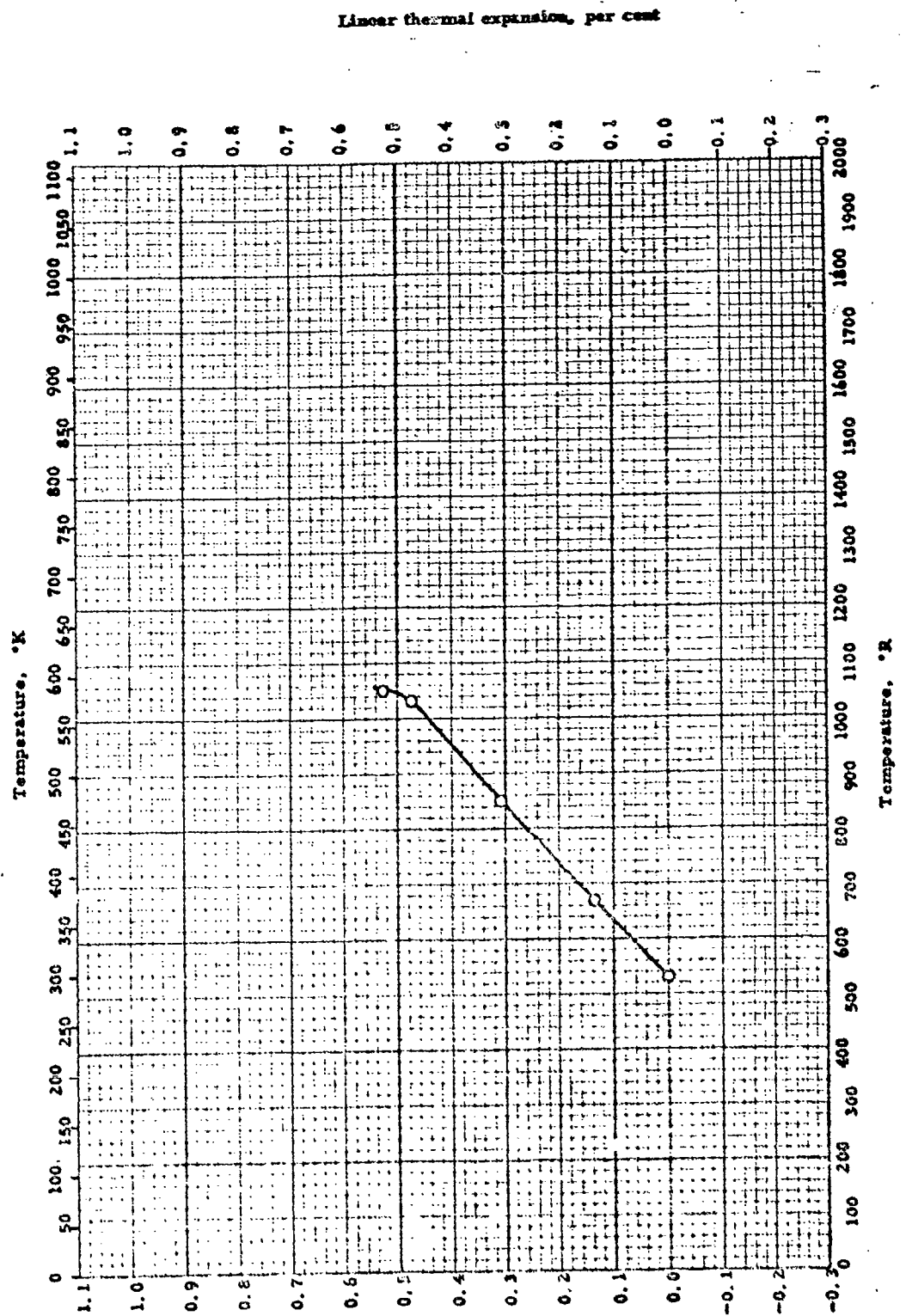
Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Skogen, H. S.	55-39	642.5 - 1165	Germanium oxide glass	Spherical calorimeter with 2 concentric shells around spherical sample. Heat input to sample meas. with precision wattmeter. Temp. by Fe-const. thermocouple	Fused in Pt 8 hr at 1400°C, furnace cooled, crushed, screened. Powder between 40 and 60 mesh. Auth. est. accuracy $\pm 8\%$

60-651

WADC TR 58-476 915

Linear thermal expansion, per cent

VII - C



LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE - MOLYBDENUM OXIDE GLASS

LINEAR THERMAL EXPANSION -- TELLURUM OXIDE - MOLYBDENUM OXIDE GLASS

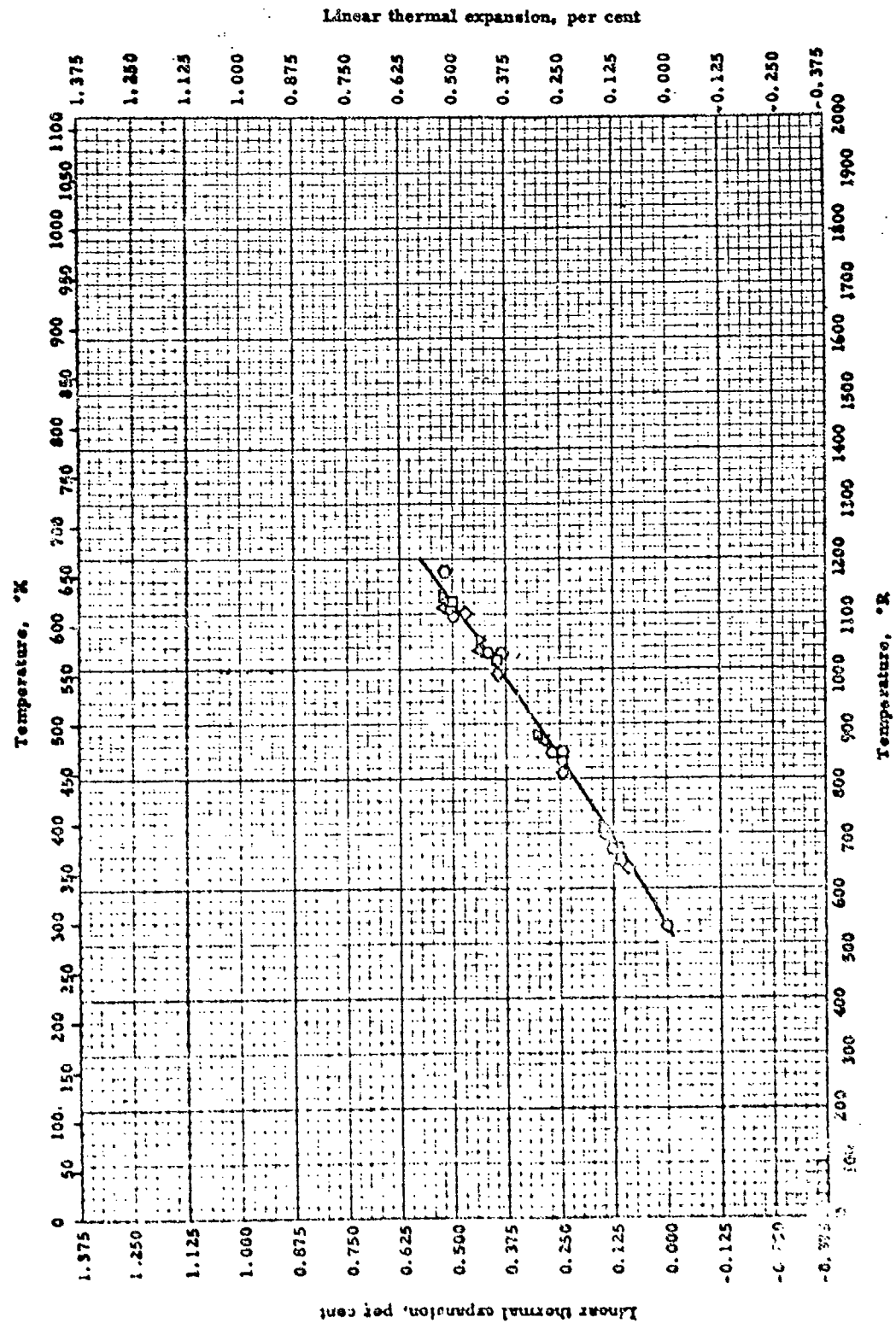
REFERENCE INFORMATION

Ref.	Investigator	Range, °K	Material Composition	Test Method	Remarks
54-140	Dale, A. E., Pegg, E. F., and Stannworth, J. E.	672-1050	65% TeO ₂ ; 31% MoO ₃ . p = 314 lb _m /ft ³	Not described here, re- fers to others	Melted in Au-C; fusible

60-731
WADC TR 58-476

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VII - C

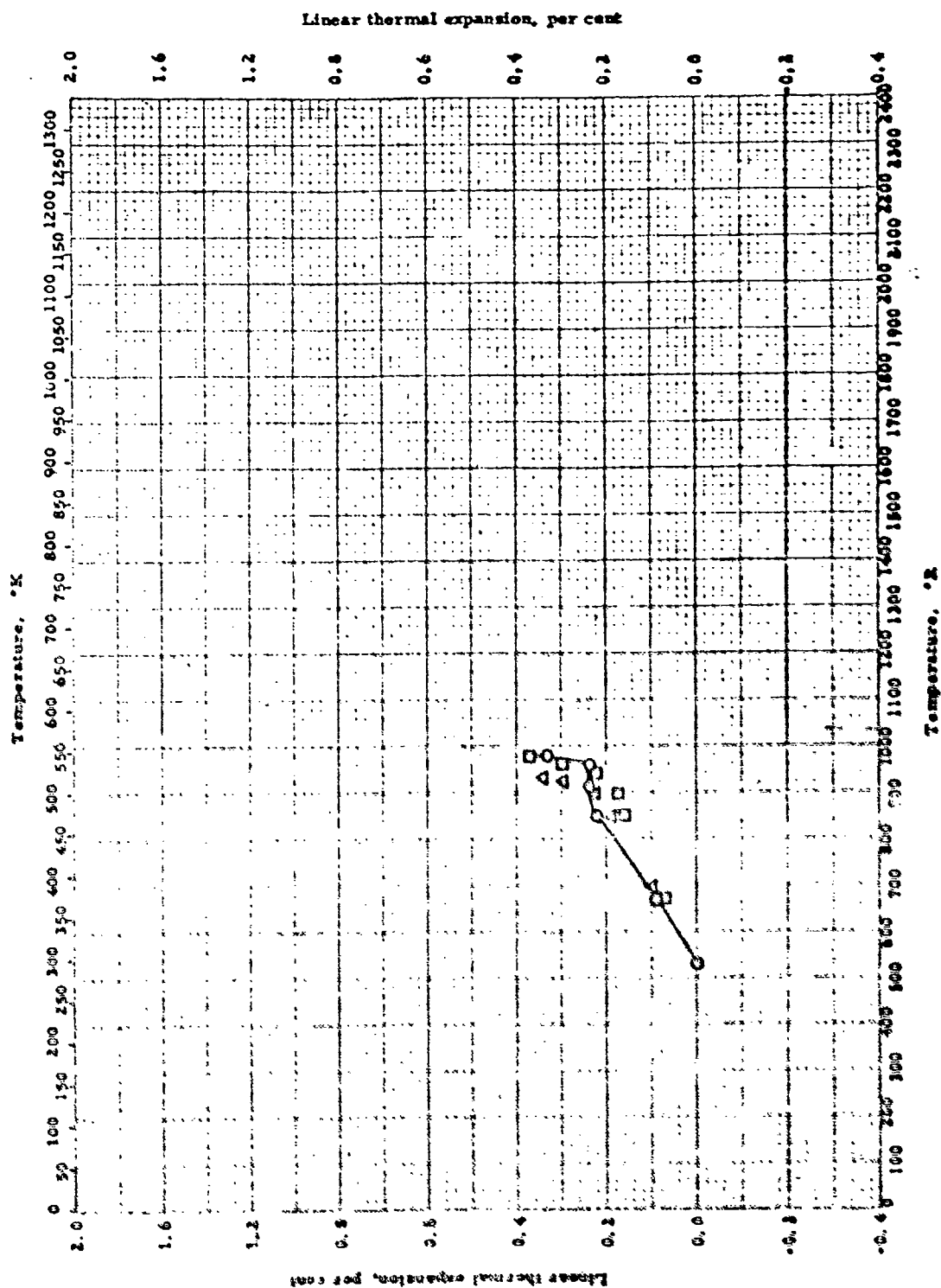


LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE-TUNGSTEN OXIDE GLASS

LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE-TUNGSTEN OXIDE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
54-140	Dele, A. E., and Pegg, E. F., and Sawyer, J. E.	672-1095	83.3% TeO ₂ ; 16.7% WO ₃ . $\rho = 364 \text{ lb}_m/\text{ft}^3$	Not described here, refers to others	Melted in Al ₂ O ₃ crucible
54-140	Dele.	672-1122	82.3% TeO ₂ ; 17.7% WO ₃ . $\rho = 366 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
54-140	Dele.	672-1104	74.1% TeO ₂ ; 20.9% WO ₃ . $\rho = 368 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
54-140	Dele.	672-1104	77.5% TeO ₂ ; 22.5% WO ₃ . $\rho = 370 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
54-140	Dele.	672-1122	75.6% TeO ₂ ; 24.4% WO ₃ . $\rho = 371 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
54-140	Dele.	672-1176	65.5% TeO ₂ ; 34.5% WO ₃ . $\rho = 379 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above

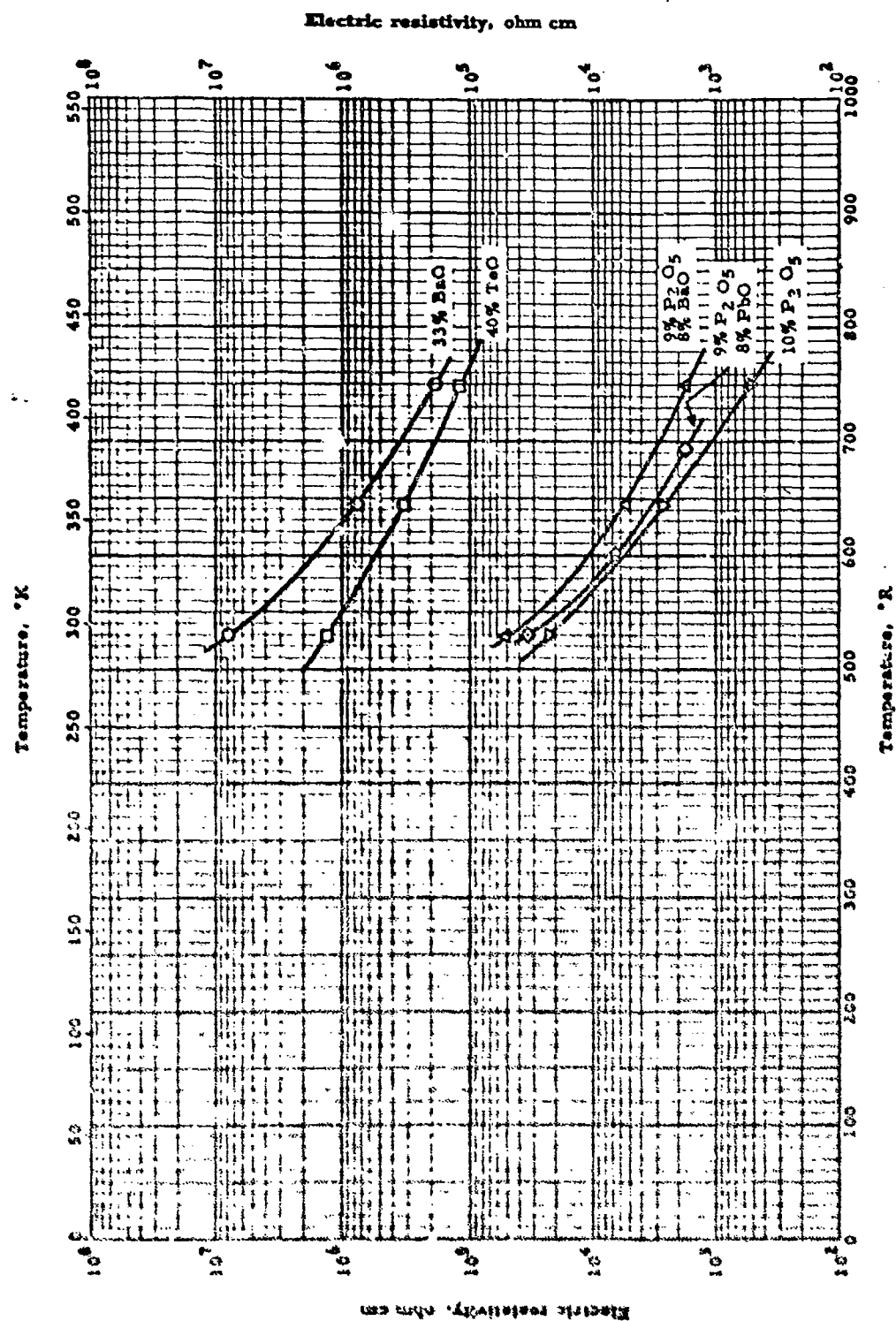


LINEAR THERMAL EXPANSION -- VANADATE GLASS

LINEAR THERMAL EXPANSION -- VANADATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	King, B. W. and Scher, L. L.	55-17	537-978	SrO + 2 V ₂ O ₅ ; 98-99 vol % glass 1 - 2 vol % V ₂ O ₅ inclusions	Interferometer	Heated to 700 °C
□	Vancso, E. P., Ravetto, R. and Stanworth, J. E.	54-139	528-978	67% V ₂ O ₅ ; 33% BaO	Not given	
Δ	BM	54-139	528-933	83% V ₂ O ₅ ; 9% P ₂ O ₅ ; 8% PbO	Not given	



ELECTRIC RESISTIVITY -- VANADATE GLASS

ELECTRIC RESISTIVITY -- VANADATE GLASS

REFERENCE INFORMATION

Ref.	Investigator	Ref. Range, °K	Material Composition	Test Method	Remarks
0	Johnson, E. P., Korshak, H. and Korshak, J. E.	54-139: 530-750	67% V ₂ O ₅ ; 33% BaO	Not given	
1	Idid.	54-139: 530-750	60% V ₂ O ₅ ; 40% TeO ₂	Same as above	
2	Idid.	54-139: 530-750	83% V ₂ O ₅ ; 9% P ₂ O ₅ ; 8% BaO	Same as above	
3	Idid.	54-139: 530-750	83% V ₂ O ₅ ; 9% P ₂ O ₅ ; 8% PbO	Same as above	
4	Idid.	54-139: 530-750	90% V ₂ O ₅ ; 10% P ₂ O ₅	Same as above	

PROPERTIES OF SILICON CARBIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	185 lb _m /ft ³	2.96 g/cm ³
Melting Point (decomposes)	5350°R *	2970°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Constitution of Binary Alloys (Ref. 58-11)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	185	2.96
□	184	2.95
△	200.4	3.210
◇	300.3	3.308

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF SILICON CARBIDE

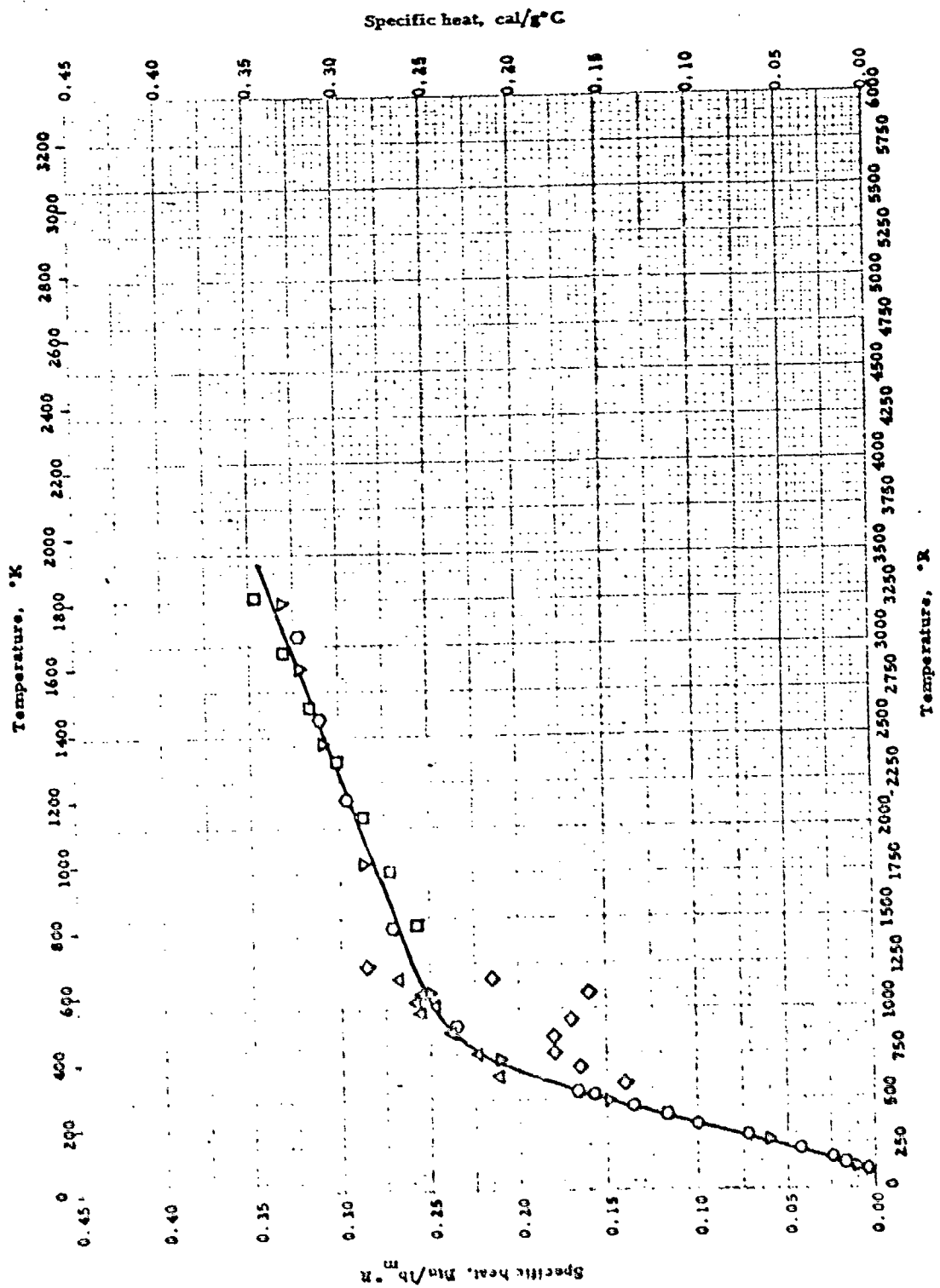
REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
53-18	Albright, E. A., Coffin, L. B. and Tinkler, J. R.	Room	SiC, 25% 1200 mesh; 40% 240 mesh; 35% 100 mesh	p: not given	Prepressed at 25,000 psi and not pressed at 10,000 psi; heated 10 min. to 4645° F
53-18	Ibid.	Room	Same as above	p: same as above	Prepressed at 2500 psi and not pressed at 10,000 psi; heated 15 min. to 4600° F. Auth. quotes theor. $\rho =$ 3.217 g/cm ³
50-68	Taylor, A. and Laidler, D. S.	Room	SiC	p: computed from X-ray measurements of lattice	β phase, cubic form
50-68	Ibid.	Room	Same as above	p: same as above	Hexagonal form, modification II, Auth. prepared many samples, containing the 2 forms in various amounts.

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59-444
WADC TR 58-476

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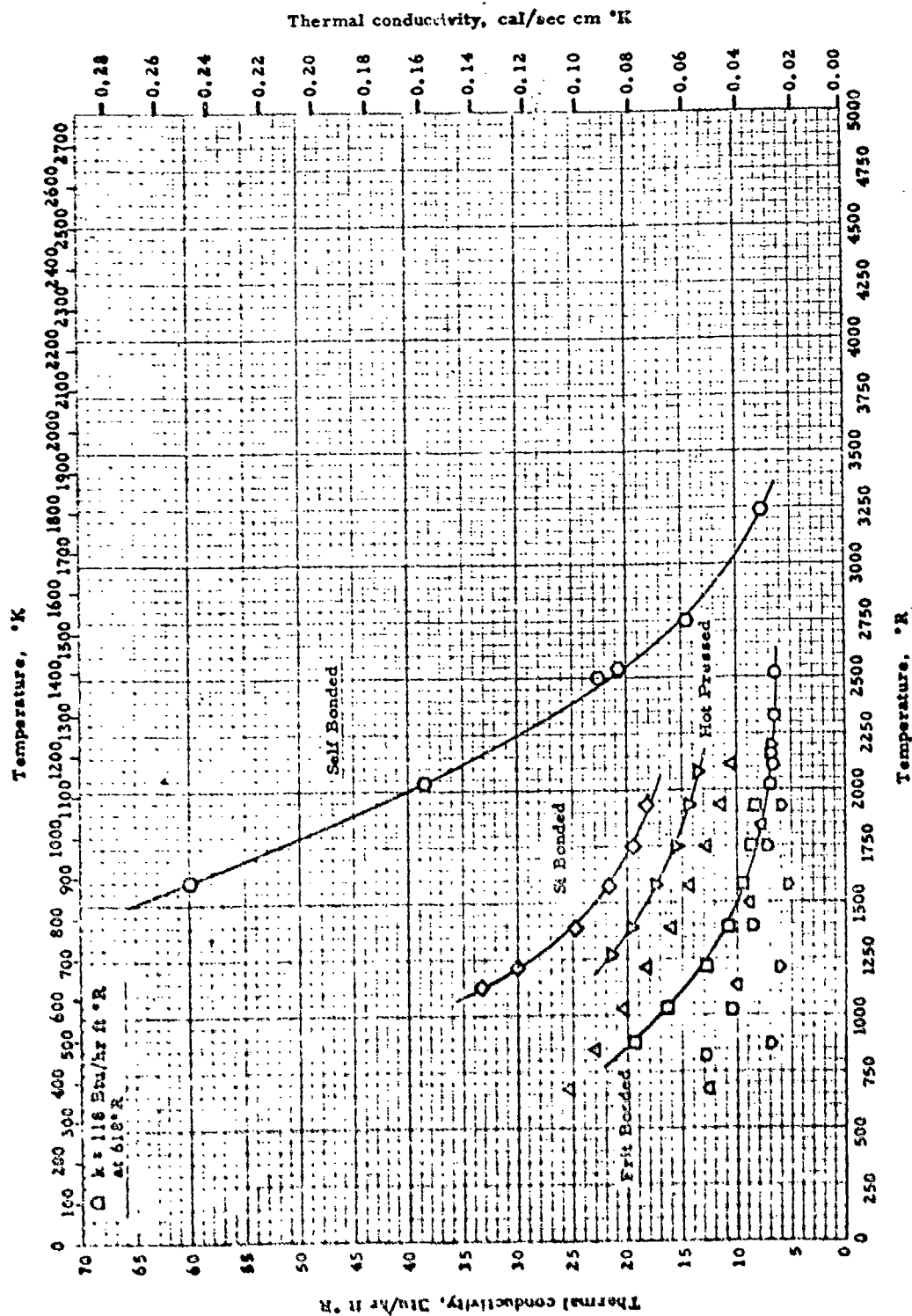


VU - D - 1 - 11

SPECIFIC HEAT -- SILICON CARBIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kailey, K. K.	41-2	98-531	99% SiC; 0.6% SiO ₂	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	Corrected for SiO ₂ impurity (assumed to be quartz) Auth. est. accuracy ± 0.5%
□	Fieldhouse, I. B., Hedge, J. C. et al.	58-4	1460-3260	Before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO. After test: 66.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO. $\rho = 511.2$ lb./ft. ³	Drop method; water calorimeter	Tested in He atmos.
△	Skogen, H. S.	55-39	636-1212	"Exolon" type, common black variety; powder between 40 and 60 mesh	Guarded sample	Auth. est. accuracy ± 8%
○	Kondo, K.	50-26	582-1302	SiC; powdered sample	Comparative; Cu standard	Tested in coal gas atmos.
▽	Humphrey, G. L.	52-134	90-3240	99.73% pure hexagonal type II SiC; 69.84% Si; 29.89% C; 0.18% Fe; 0.03% Al; <0.01% Ca	Drop method	For 298 to 1800°K, c_p calc. from author's eq., $c_p \left(\frac{\text{cal}}{\text{g mole} \cdot ^\circ\text{C}} \right) = 9.93 + 0.00192 T (^\circ\text{K}) - 366,000 T (^\circ\text{K})^{-2}$
○	Ibid.	52-134	90-3060	Cubic type SiC; <1% hexagonal SiC; 0.34% free C; 0.17% SiO ₂ ; 0.06% Al; 0.013% free Si; 0.004% Fe	Same as above	For 298 to 1800°K, c_p calc. from author's eq., $c_p \left(\frac{\text{cal}}{\text{g mole} \cdot ^\circ\text{C}} \right) = 9.97 + 0.00182 T (^\circ\text{K}) - 364,000 T (^\circ\text{K})^{-2}$

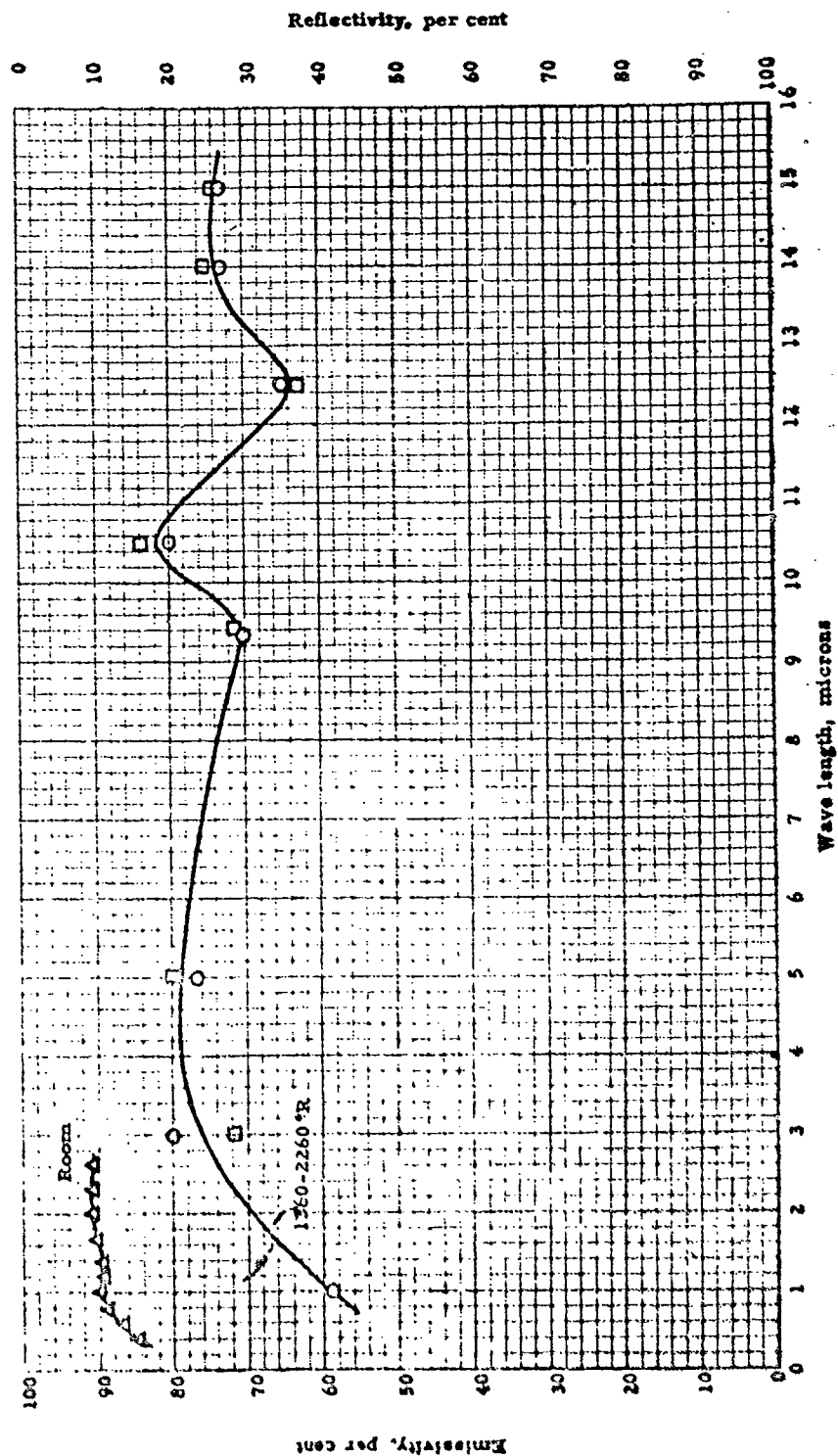


THERMAL CONDUCTIVITY -- SILICON CARBIDE

THERMAL CONDUCTIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
57-26	Clements, A. F. and Vyse, J.	2022-2517	Silicon carbide brick; 1.71% Al ₂ O ₃ ; SiO ₂ , TiO ₂ , Fe ₂ O ₃ , CaO, MgO, K ₂ O, Na ₂ O not detected. $p = 157 \text{ lb}_m/\text{ft}^3$. Apparent porosity = 17.8%	Not adequately described	Auth. est. accuracy $\pm 5\%$
55-25	Norton, F. H. and Kingery, W. D.	888-1932	Commercial frit bonded	Comparative; rods	Run in vacuum
54-24 also 53-40 also 53-41	Vasilev, T. and Kingery, W. D.	672-2112	Cut from ingot	Comparative; rods	
55-25	Norton, F. H. and Kingery, W. D.	1122-1932	Silicon bonded (consists of continuous Si phase and cubic SiC)	Comparative; rods	
55-25	Dtd.	1266-2076	Hot pressed	Same as above	
58-4	Feldhouse, I. R., Hodge, J. C. et al.	1600-3242	SiC bonded. Before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO. After test: 68.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO. $p = 193 \text{ lb}_m/\text{ft}^3$	Single flat plate; boiling liq. calorimeter	Run in He atmos.
53-17 also 52-49	Weeks, J. L. and Seifert, R. A.	618	Polycrystalline; $p = 175 \text{ lb}_m/\text{ft}^3$	Comparative; rods	Run in vacuum
56-160	Gurukul, R., Kuyayama, M. and Yamashita, T.	672-1842	Carbofrax; 89% SiC; 16.52% porosity	Calorimetric method of steady state heat flow	Carbofrax made by Carborundum Co.
54-142	Norton, F. H. and Kingery, W. D.	816-2160	SiC, frit bonded, commercial sample	"Linear flow tester"	Sample 1
54-142	Dtd.	670-2202	Same as above	Same as above	Sample 2



SPECTRAL EMISSIVITY -- SILICON CARBIDE

SPECTRAL EMISSIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Stewart, J. E. and Richmond, J. C.	57-126	2260	Silicon carbide, Globar (recrystallized silicon carbide)	Spectral emissivity: Comparative: surface brightness compared with that of a standard meas. against black body Same as above	
□	Idid.	57-126	1360	Same as above	Spectral reflectivity at 9°: Sample compared with Mg CO ₃ standard in MgO integrating sphere, quartz lens, PbS detector	
△	Gleason, O. H. and Morris, J. C.	59-1	Room	Silicon carbide		

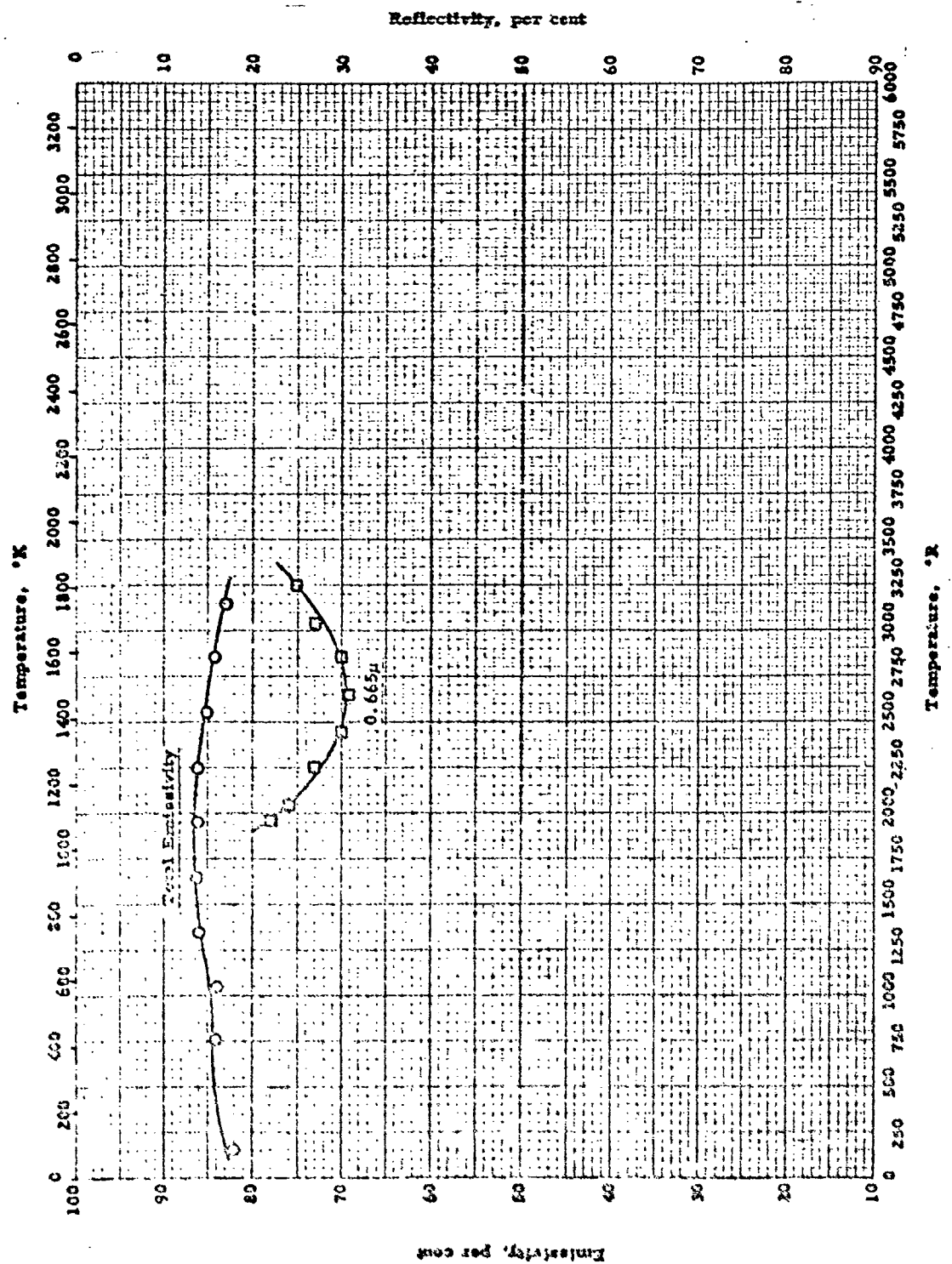
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WADC TR 58-476

931

VII - D - 1 - A



EMISSION -- SILICON CARBIDE

EMISSIVITY -- SILICON CARBIDE

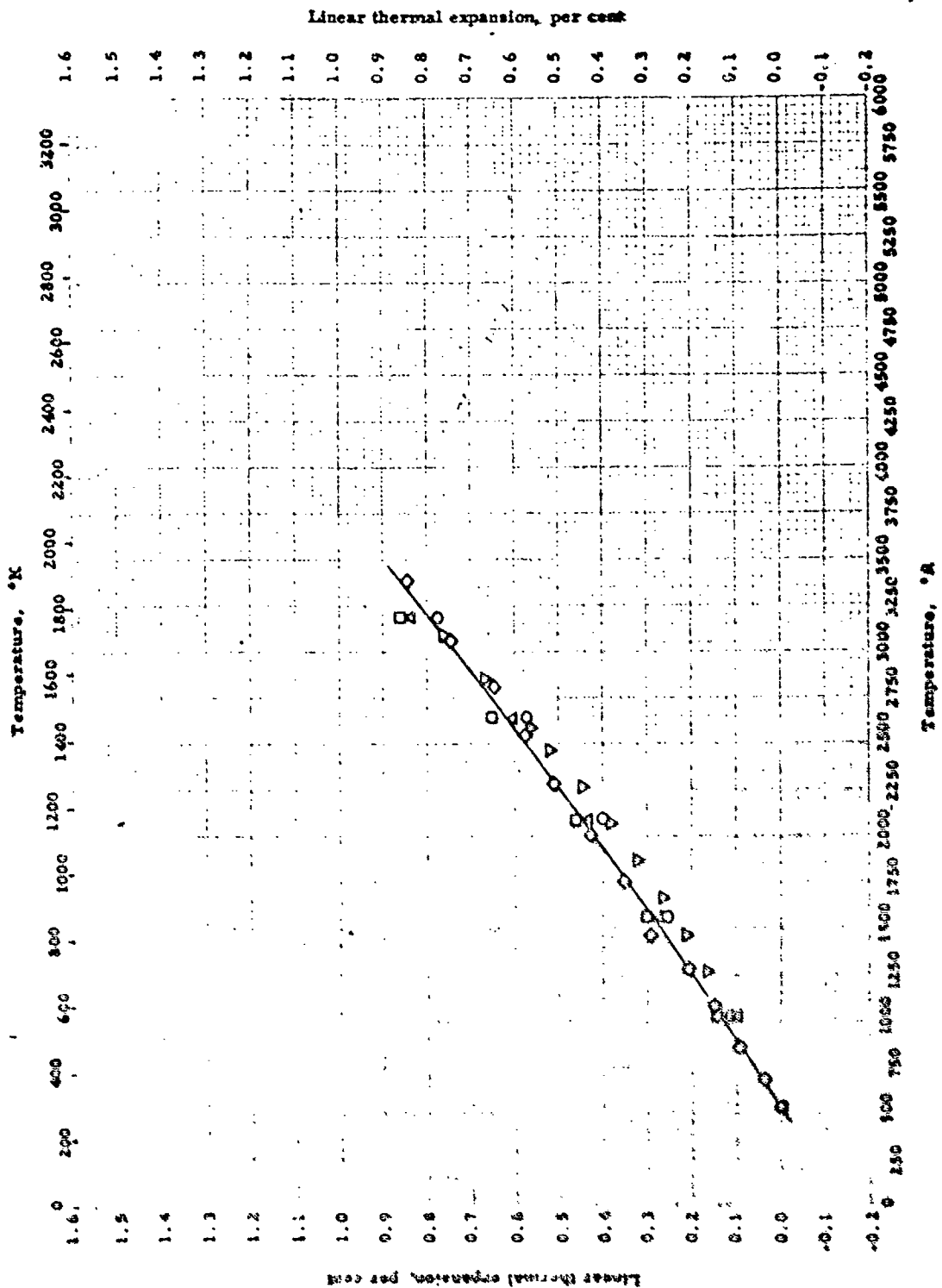
REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
0	Glenn, O.H. and Morris, J.C.	59-1	160-2700	Not given	Total normal emissivity: comparative; radiant heat flow compared with that of a black body, thermopile; sample temp. by thermocouple	Sample in air
□	Eds.	59-1	1960-3250	Not given	Spectral normal emissivity at 0.665μ: comparative; surface brightness compared with that of a black body hole, disappearing filament optical pyrometer; sample temp. by thermocouple	

59-1142

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952



59-1170
WADC TR 58-416 933

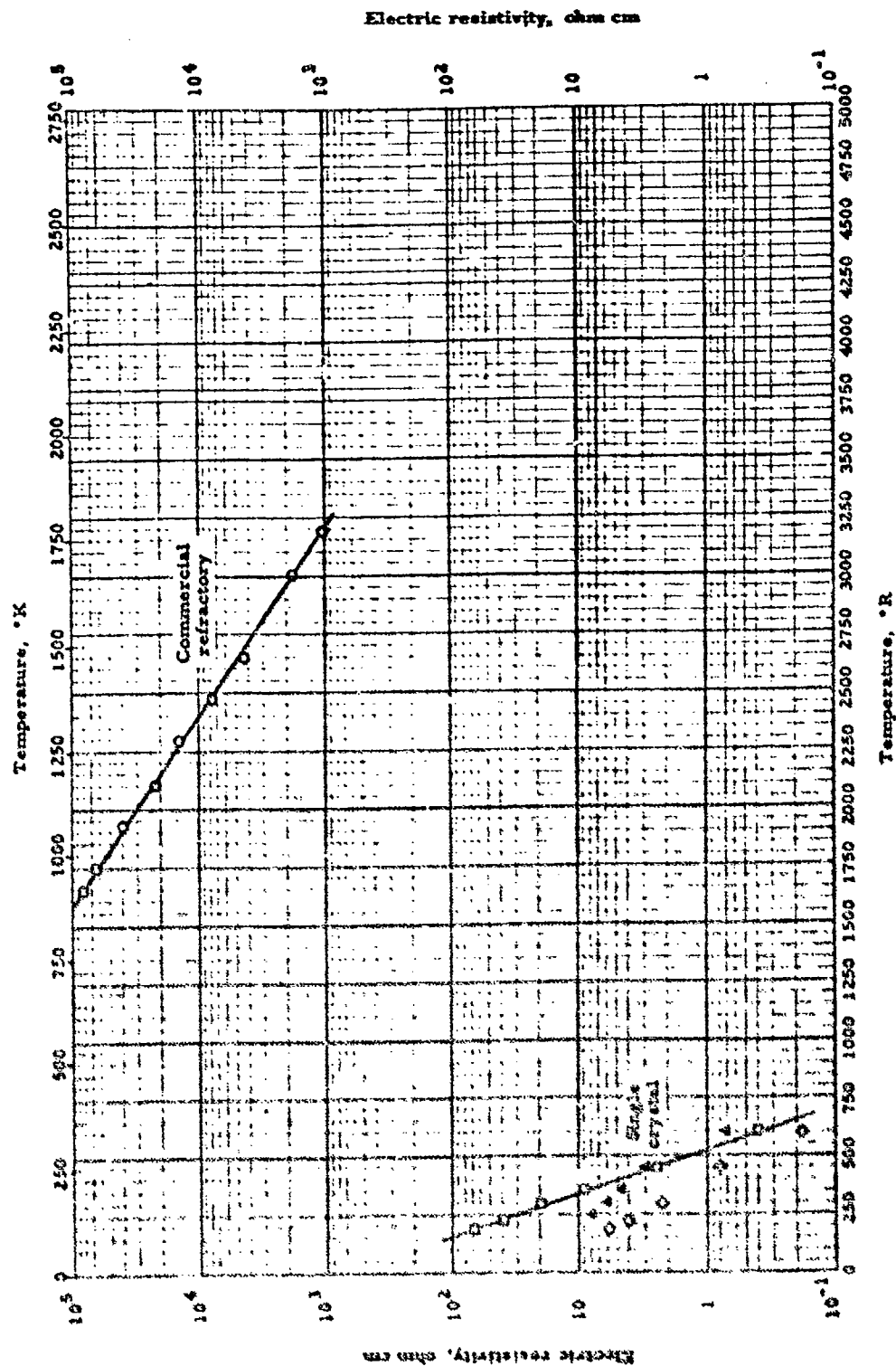
LINEAR THERMAL EXPANSION -- SILICON CARBIDE

W-1-D-1-1

LINEAR THERMAL EXPANSION -- SILICON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	T-est Method	Remarks
1	Whittemore, O. J. and Auld, N. N.	56-7	1032-3192	Silicon carbide (recrystallized)	Telemicroscopes sighting on pointed ends of sample	
2	Ibid.	56-7	1032-3192	Silicon carbide (clay-bonded)	Same as above	
3	Ibid.	56-7	1032-3192	Silicon carbide (bonded glazed brick)	Same as above	
4	Fitchouse, L. D., Hedge, J. C. et al.	56-4	540-3383	Before test: 67.46% Si; 23.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO After test: 68.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO	Telemicroscopes sighting on samples	
5	Seibel, R. D. and Mason, G. L.	57-156	1260-3060	Silicon Carbide	Alumina tube dilatometer with differential transformer pick- up	In vacuum of $10^{-6} - 10^{-7}$ mm Hg



59-1098
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VII-D-1-a

ELECTRIC RESISTIVITY -- SILICON CARBIDE

ELECTRIC RESISTIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Chiodo, V. E. J. and Henry, E. G.	53-94	1662-3192	Commercial refractory. Comp. not given	Wheatstone bridge at 965 cycles	Apparent porosity 12%
Q	Scrull, W.	52-98	180-600	Cut from single crystal	Not given	Black sample No. 1
Δ	Did.	52-94	180-600	Same as above	Same as above	Green sample
◇	Did.	52-96	180-600	Same as above	Same as above	Black sample No. 2

PROPERTIES OF SILICON CARBIDE + BORON CARBIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	187 lb _m /ft ³ *	3.00 g/cm ³ *
Melting Point.		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* For 15% B₄C

REPORTED VALUES

Density: lb_m/ft³ g/cm³
 O 187 3.00

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

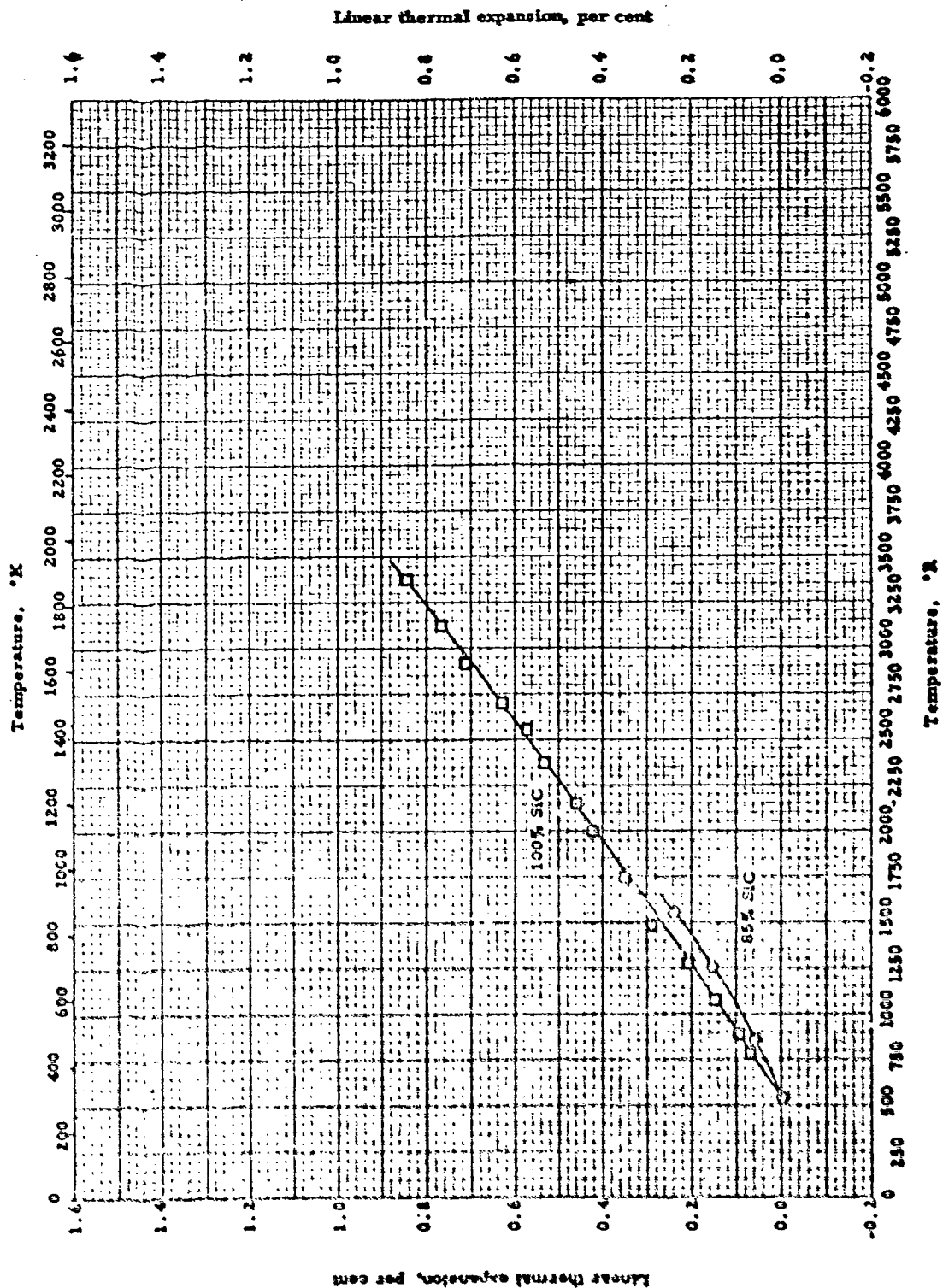
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF SILICON CARBIDE + BORON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
59-737 Dec	Gangier, J. J.	50-10	85% silicon carbide; 15% boron carbide; 59.89% Si; 14.36% B; 22.21% combined C; 3.02% free C	p: weight in air and in distilled water	Samples fabricated by hot pressing in graphite mold



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59-840

WADC TR 58-476

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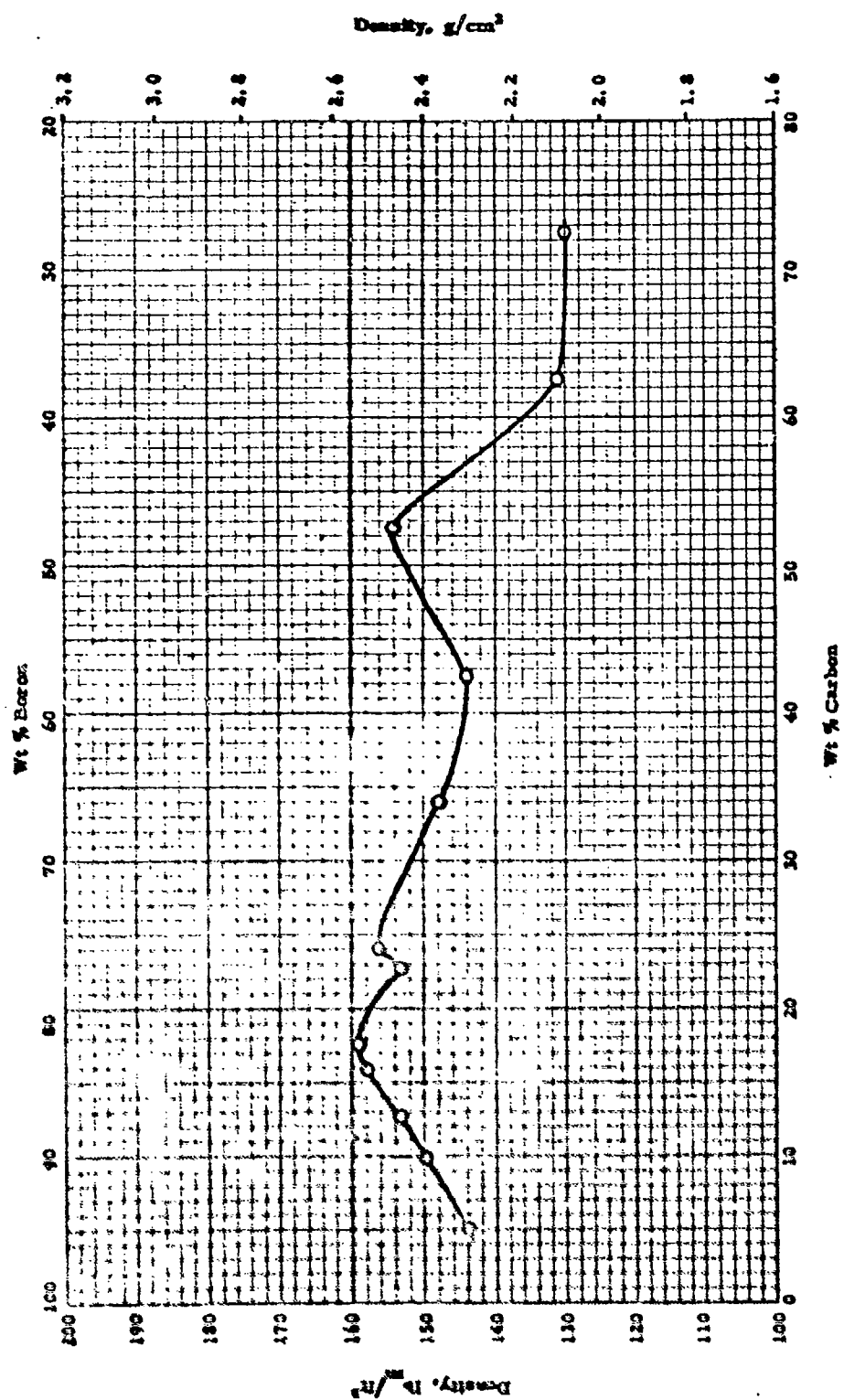
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LINEAR THERMAL EXPANSION -- SILICON CARBIDE + BORON CARBIDE

LINEAR THERMAL EXPANSION -- SILICON CARBIDE + BORON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Gangler, J. J.	50-10	540-1560	Approx. 85% SiC; 15% B ₄ C; analyzed as 59.89% Si; 22.21% combined C; 14.36% B; 3.92% free C; $\rho = 187.2 \text{ lb./ft.}^3$	Interferometer	Hot pressed in graphite mold; tested at 4°C/min, rise
□	Fiala, L. B.; Madge, J. C. et al.,	58-4	540-3383	Silicon carbide; before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO; after test: 68.12% Si; 27.29% C; 1.97% Al; 0.32% Fe; 0.44% CaO	Telemicroscopes eighting on samples	



DENSITY -- BORON CARBIDE

DENSITY -- BORON CARBIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O Sarnacev, O. V. Zboravsky, N. M. and Amend, I. G.	66-151	Room	S. 11-72, 5% C. Prepared from 99.9% pure B and 99.9% pure lampblack	Pycnometric weighing in xylene	Hot pressed; stress relieved and homogenized in vacuum furnace; slowly cooled

PROPERTIES OF BORON CARBIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	156 lb _m /ft ³	2.5 g/cm ³
Melting Point	4860+ °R*	2700+ °K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* High Temp. Technology by Campbell (Ref. 56-54)

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	156	2.50
□	156	2.50

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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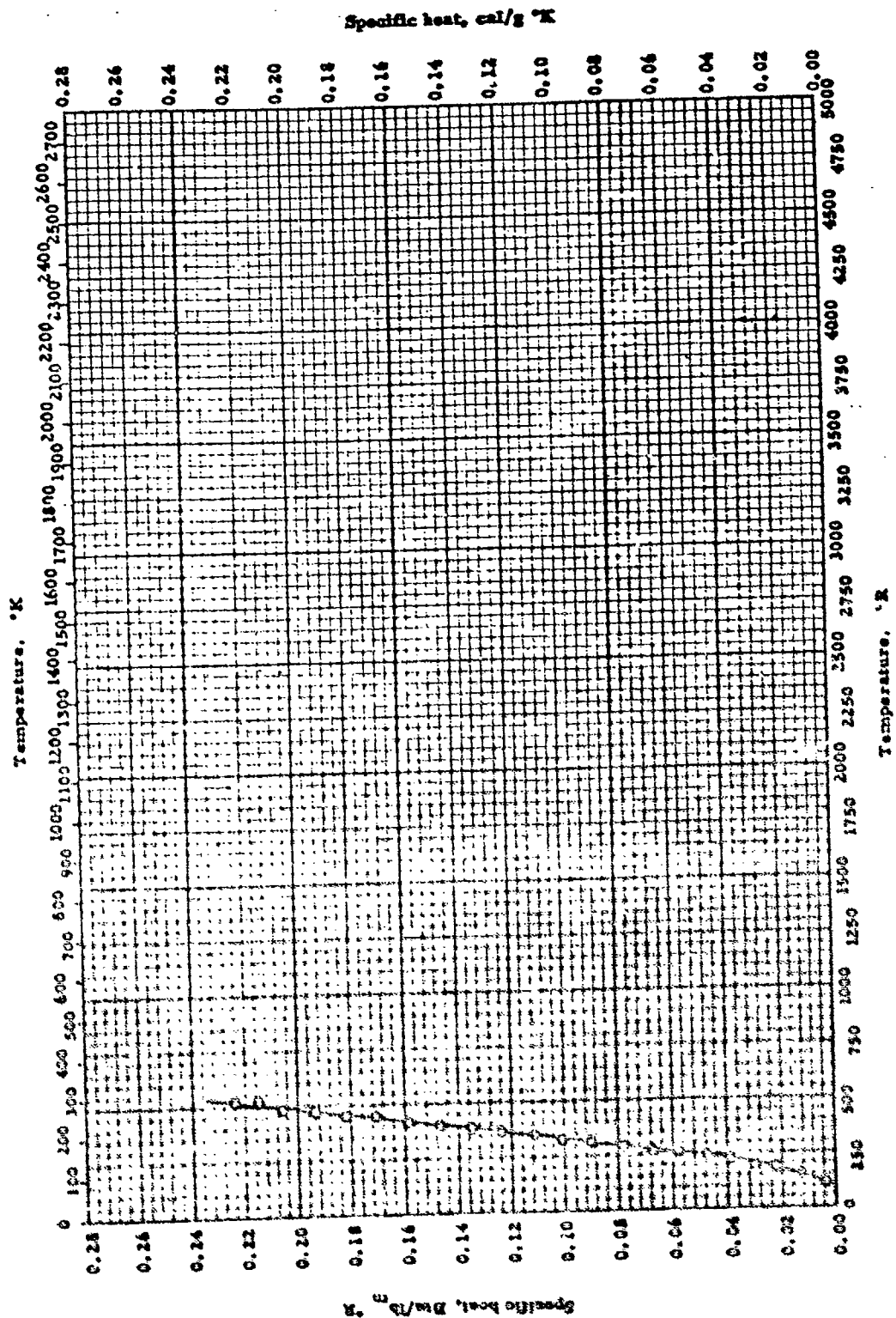
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF BORON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Gangler, J. J.	50-10	Room	79.08% B; 10.79% combined C; 3.85% free C	p: weight in air and in distilled water	Fabricated by hot pressing in graphite mold. Auth. gives theor. $p = 2.52 \text{ g/cm}^3$
Q	Mannan, H. J. and Lidman, W. G.	52-78	Room	76.6% B; 23.54% C; 0.06% Fe	p: not given	



SPECIFIC HEAT - BORON CARBIDE

SPECIFIC HEAT -- BORON CARBIDE

REFERENCE INFORMATION

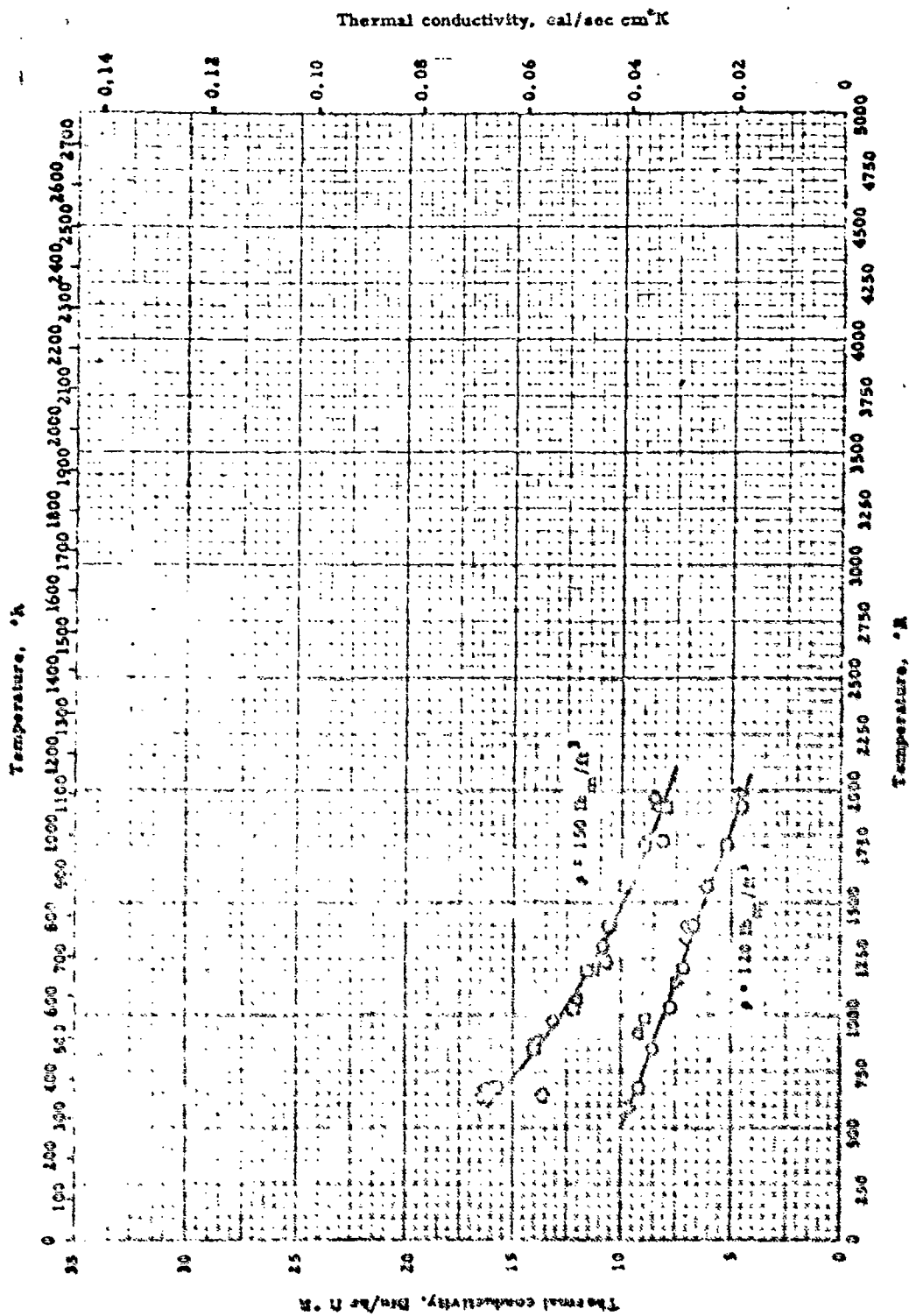
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O Kallay, R. R.	41-2	98-130	98% B ₄ C, 6% free and included graphite	Comparative: rate of temp. rise in sample compared with that in standard under same heating conditions	Corrected for graphite; auth. est. accuracy within 0.5%

59-537

WADC TR 55-476

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THERMAL CONDUCTIVITY -- BORON CARBIDE

REFERENCE INFORMATION

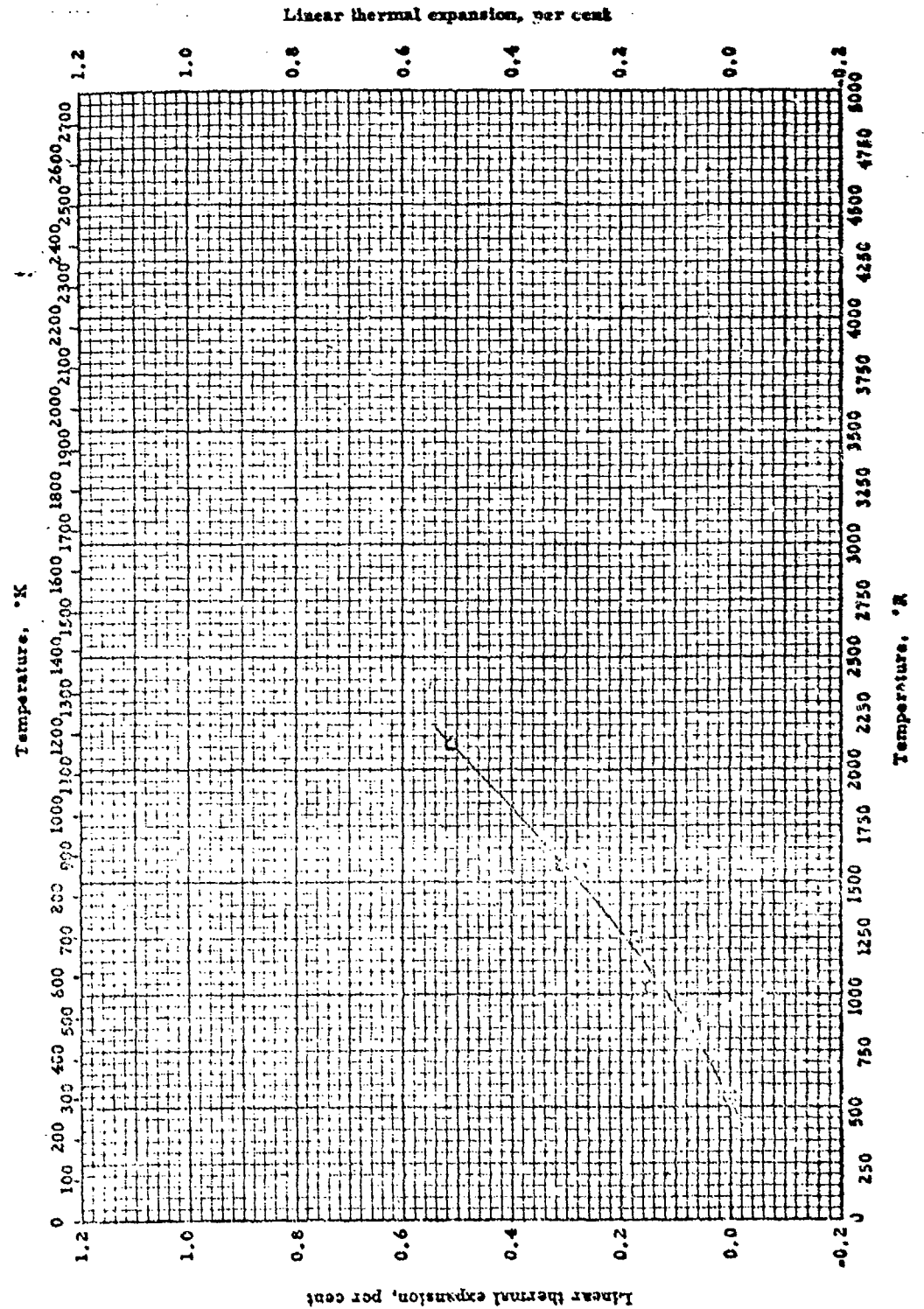
	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Deem, H. W. and Lucks, C. F.	51-46	672° to 1932°	Boron carbide (No. D11, 798-1) $p = 119 \text{ lb}_m/\text{ft}^3$	Comparative; rods. (Armco iron standard)	Tested in vacuum
E	Deem, H. W. and Lucks, C. F.		672° to 1932°	Boron carbide (Norton No. D11 776-2) $p = 145 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
Δ	Deem, H. W. and Lucks, C. F.		672° to 1932°	Boron carbide 77.1% B; 22.2% C; (B _{1.4} C) $p = 156 \text{ lb}_m/\text{ft}^3$	Same as above	Hot pressed; tested in vacuum
◇	McGright, L. R.	57-143	654-1932	Boron carbide, 2 samples: a. $p = 156 \text{ lb}_m/\text{ft}^3$ b. $p = 145 \text{ lb}_m/\text{ft}^3$	Two methods: a. comparative, rods b. axial heat flow in rod	Plotted avg. of two samples, agreeing within $\pm 1\%$
▽	EMC.	57-148	591-1977	Boron carbide, $p = 119 \text{ lb}_m/\text{ft}^3$	Same as above	Rammed and sintered
○	EMC.	57-148	545-1770	Boron carbide, $p = 118 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above
□	EMC.	57-148	960-1374	Boron carbide with 1.85% sodium silicate binder $p = 127 \text{ lb}_m/\text{ft}^3$	Same as above	Rammed with sodium silicate binder
◊	EMC.	57-148	960-1329	Boron carbide with 2.15% sodium silicate binder $p = 129 \text{ lb}_m/\text{ft}^3$	Same as above	Same as above

59-221

WADC TR 58-476

949

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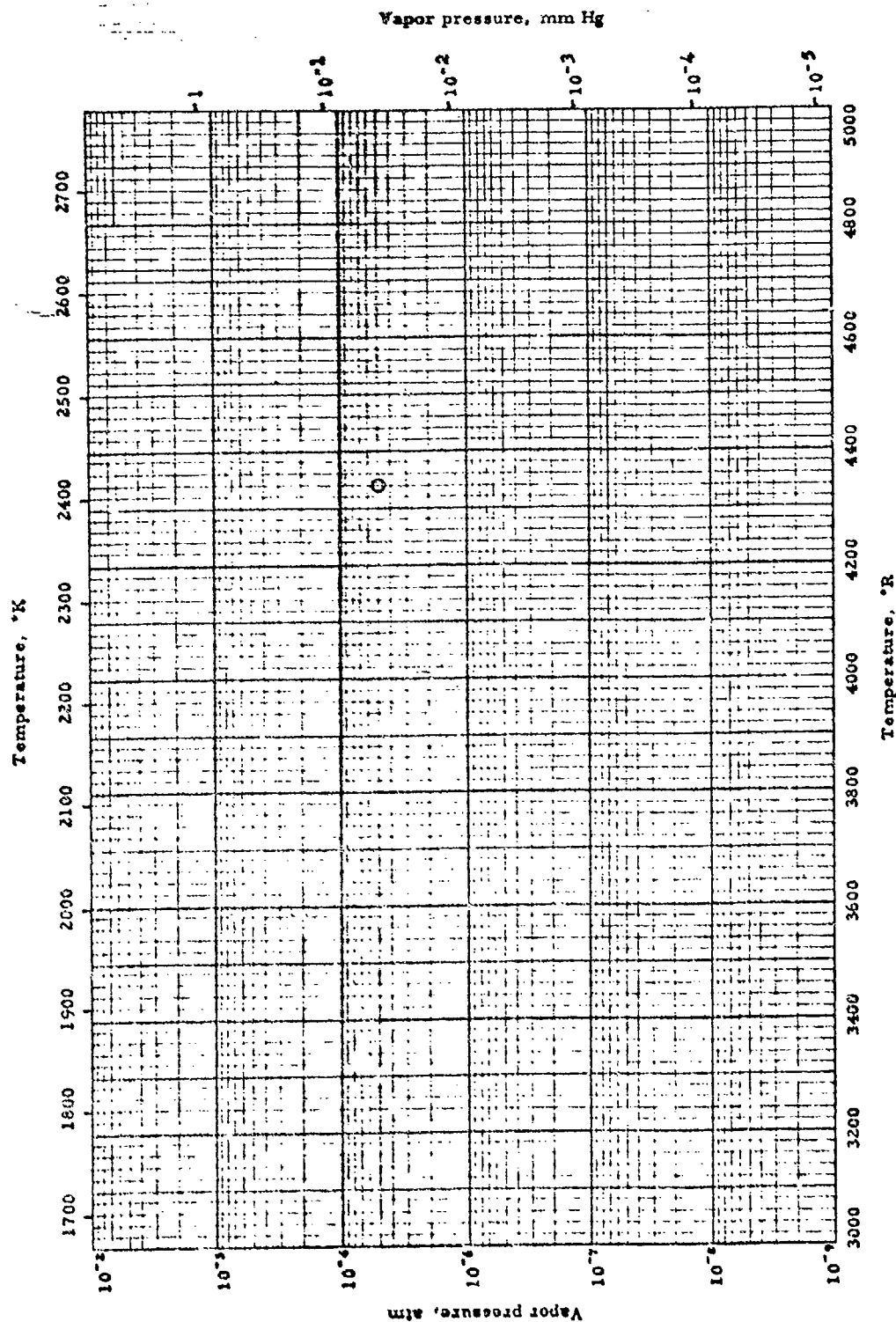


LINEAR THERMAL EXPANSION -- BORON CARBIDE

LINEAR THERMAL EXPANSION -- BORON CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-7	Whittemore, O. J. and Ault, N. N.	1032-2112	Not given	Telemicroscopes eight- ing on pointed ends of sample	Hot molded
50-10	Gangler, J. J.	540-1560	79.08% B; 10.79% combined C; 3.85% free C; $\rho = 156 \text{ lb}_m/\text{ft}^3$	Interferometer	Hot pressed in graphite mold; tested at 4°C/min, rise



VAPOR PRESSURE -- BORON CARBIDE

VAPOR PRESSURE -- BORON CARBIDE

REFERENCE INFORMATION

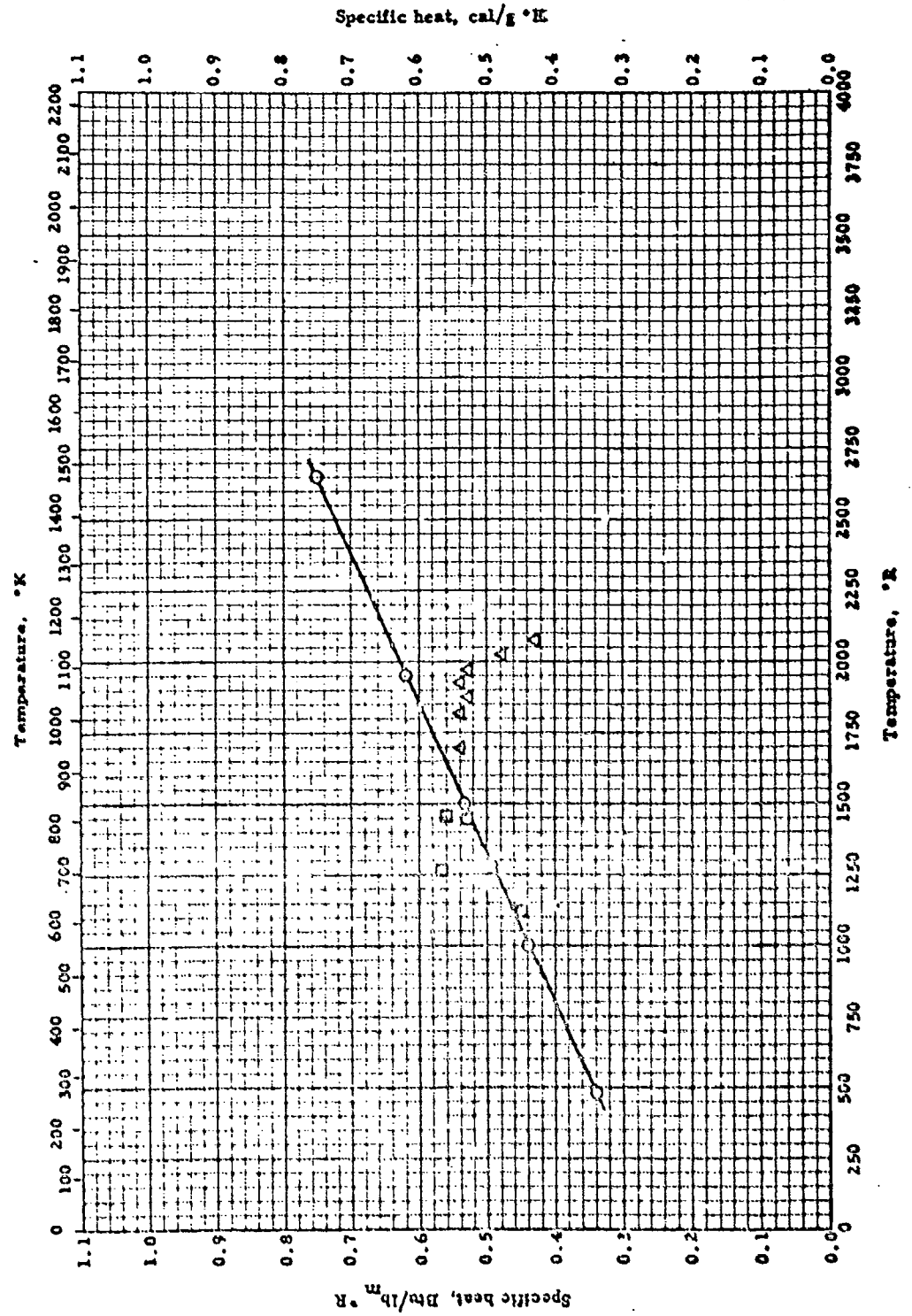
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
56-154	Gilles, P. W. and Robson, H. E.	4340	B ₄ C. 77.50% B; 22.20% C; 0.07% Fe	Langmuir effusion method	Auth. believe B ₄ → 4B(g) + C(s) with little B ₄ → 4B(g) + C(g). Calc. based only on B(g) in vapor

59-828

WADC TR 58-476

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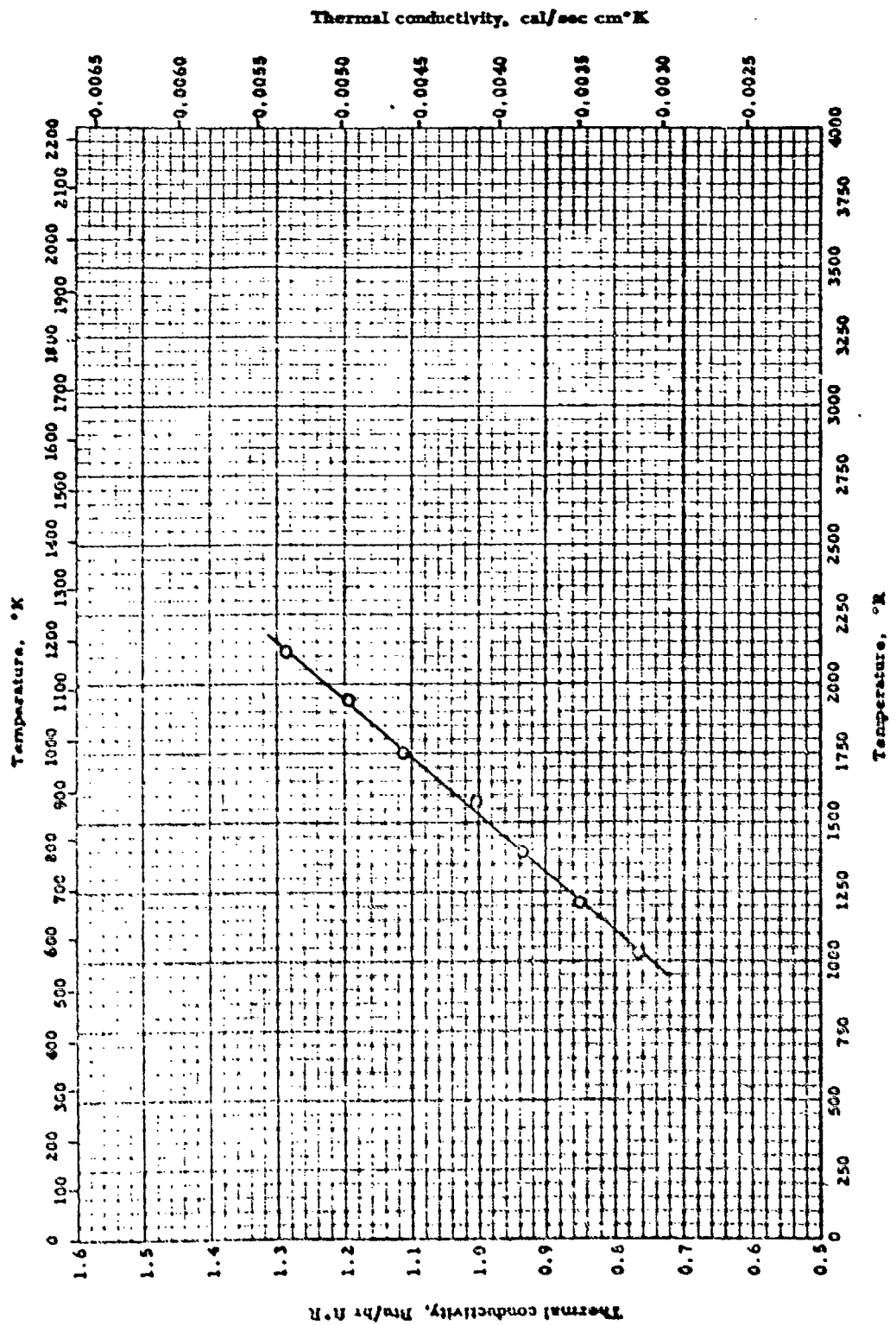


SPECIFIC HEAT -- BERYLLIUM CARBIDE

SPECIFIC HEAT -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
50-19 also 43-16	Neely, J. J., Teeter, C. E. and Trice, J. B.	492-2652		Be ₂ C. Before test: 80% pure, most of im- purities were oxide and nitride. After test: 74% Be ₂ C	Drop method; copper block calorimeter	Auth. est. accuracy $\pm 10 - 15\%$. Not corrected for impurities
43-13	Trice, J. B., Neely, J. J. and Teeter Jr., C. E.	1125-1455		Be ₂ C; 56.5% Be; 1.14% free C; 0.065% free Fe. Powdered sample	Drop method, copper block inside water calorimeter	Auth. est. accuracy $\pm 15\%$. Auth. recommends $c_p = 0.5 \pm 0.1 \text{ Btu/lb}_m \cdot ^\circ R$
43-14	Trice, J. B., Neely, J. J. and Teeter Jr., C. E.	1700-2075		Be ₂ C. Left end: 52.45% Be; 1.94% free C Middle: 48.65% Be; 3.39% free C Right end: 50.24% Be; 1.96% free C (theoretical 60.05% Be)	Measuring the rate of temp. drop during cooling	Not pressed hollow cylin- der made by Norton. Auth. est. accuracy $\pm 25\%$. Auth. recommends $c_p = 0.5 \pm 0.1 \text{ Btu/lb}_m \cdot ^\circ R$

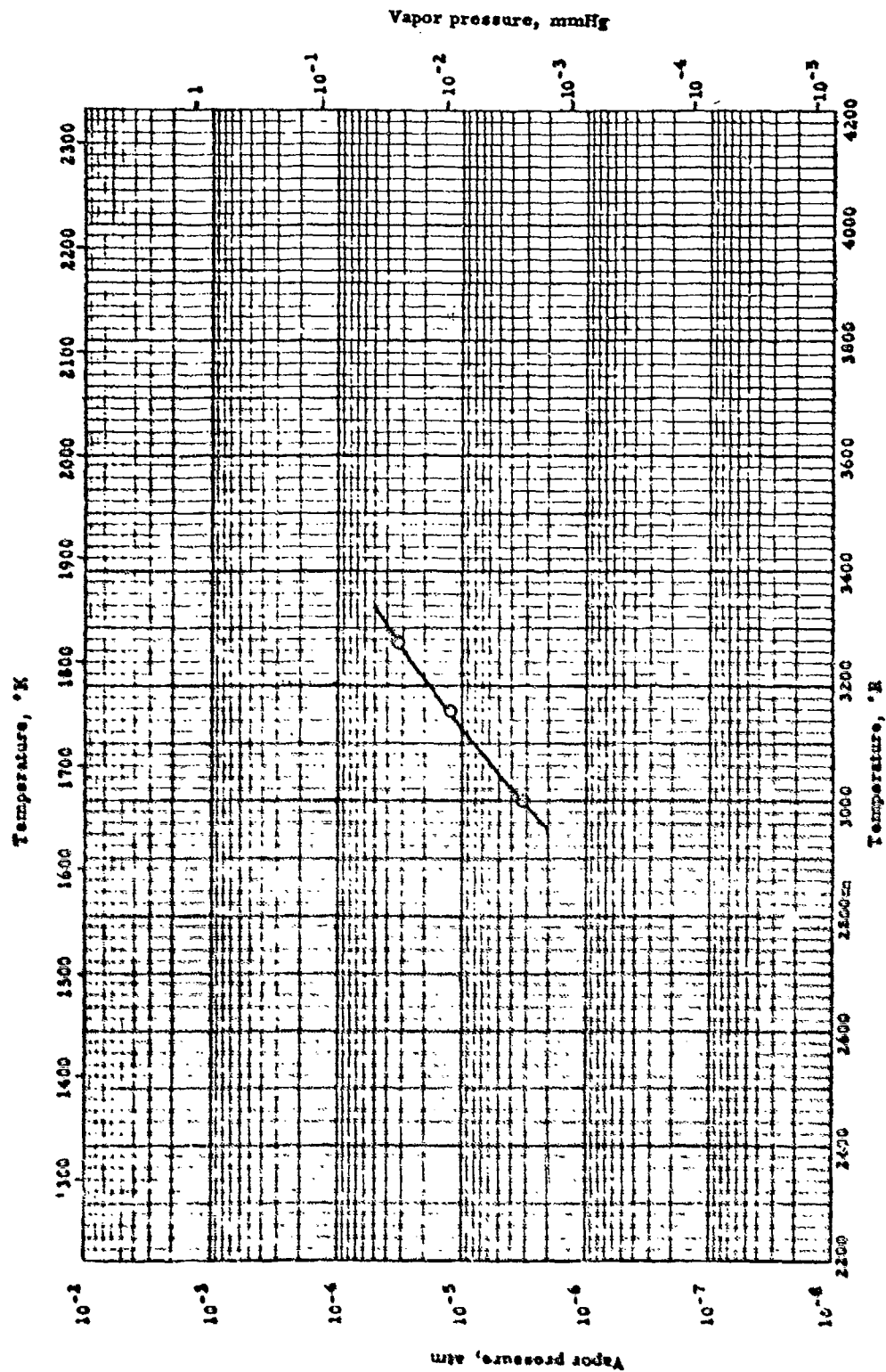


THERMAL CONDUCTIVITY -- BERYLLIUM CARBIDE

THERMAL CONDUCTIVITY -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

Sym Eol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Neely, J. I. Teeter, C. E. and Trice, J. E.	50-19 also 48-16	1032-2112	80% Be ₂ C; impurities mostly BeO and Be ₃ N ₂	Radial heat flow in cyl- inder	Auth, est, accuracy ± 200%



VAPOR PRESSURE-BERYLLIUM CARBIDE

VAPOR PRESSURE -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

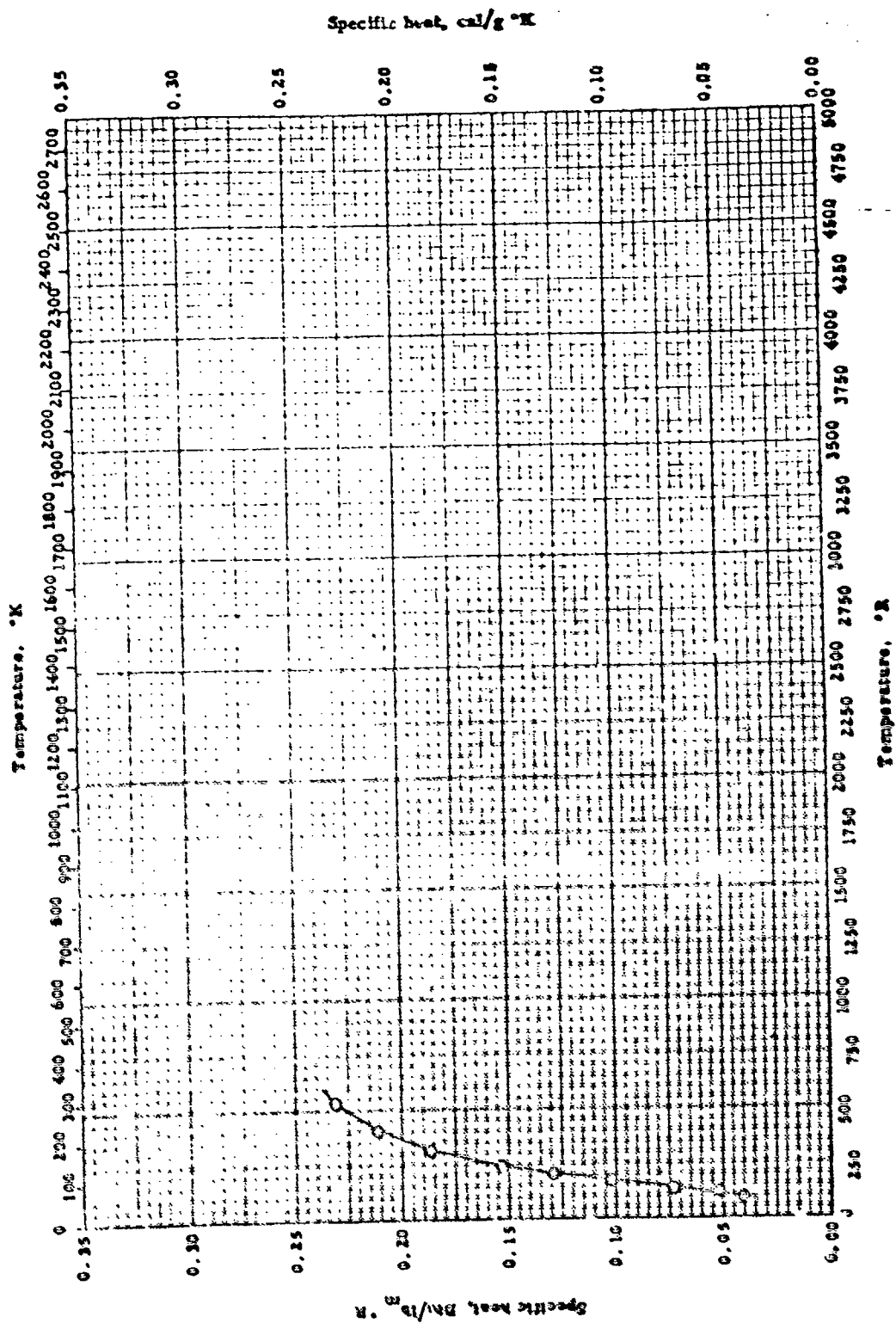
Symbol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
O	Yasim, S. J. and Mills, T. A.	57-145	3000-3273	Be ₂ C. Plotted Be(g) from the equation $1/2 \text{Be}_2\text{C(s)} \rightarrow \text{Be(g)} + 1/2 \text{C(g)}$	Knudsen method in graphite crucible	

59-96

WADC TR 53-476

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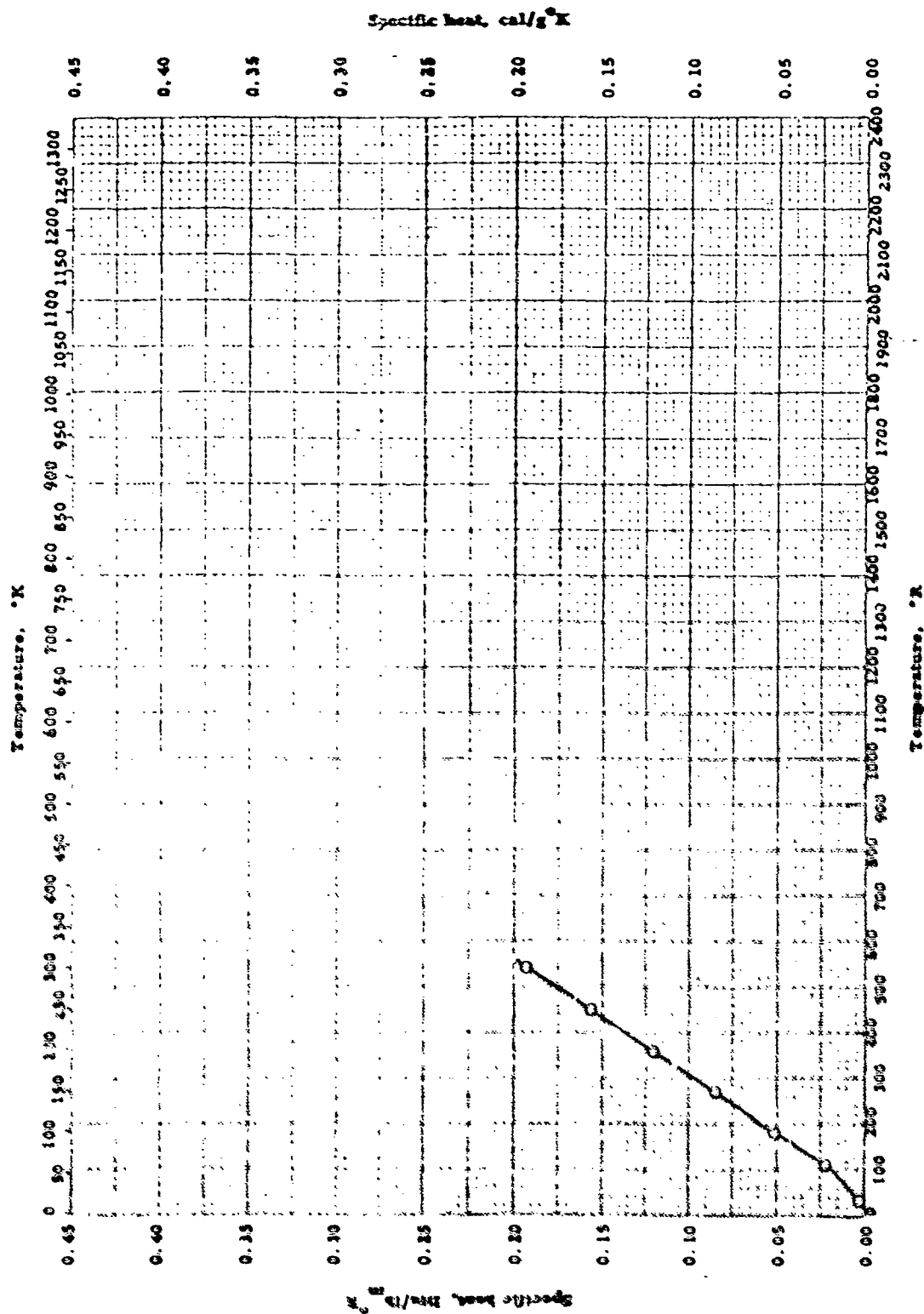


SPECIFIC HEAT -- CALCIUM CARBIDE

SPECIFIC HEAT -- CALCIUM CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kelley, K. K.	41-16	96-532	91.0% CaC ₂ ; 6.47% CaO; 1.15% SiO ₂ ; 0.77% Al ₂ O ₃ ; 0.2% C; 0.08% MgO; 0.29% FeS	Guarded sample	



SPECIFIC HEAT -- BORON NITRIDE

SPECIFIC HEAT -- BORON NITRIDE

REFERENCE INFORMATION

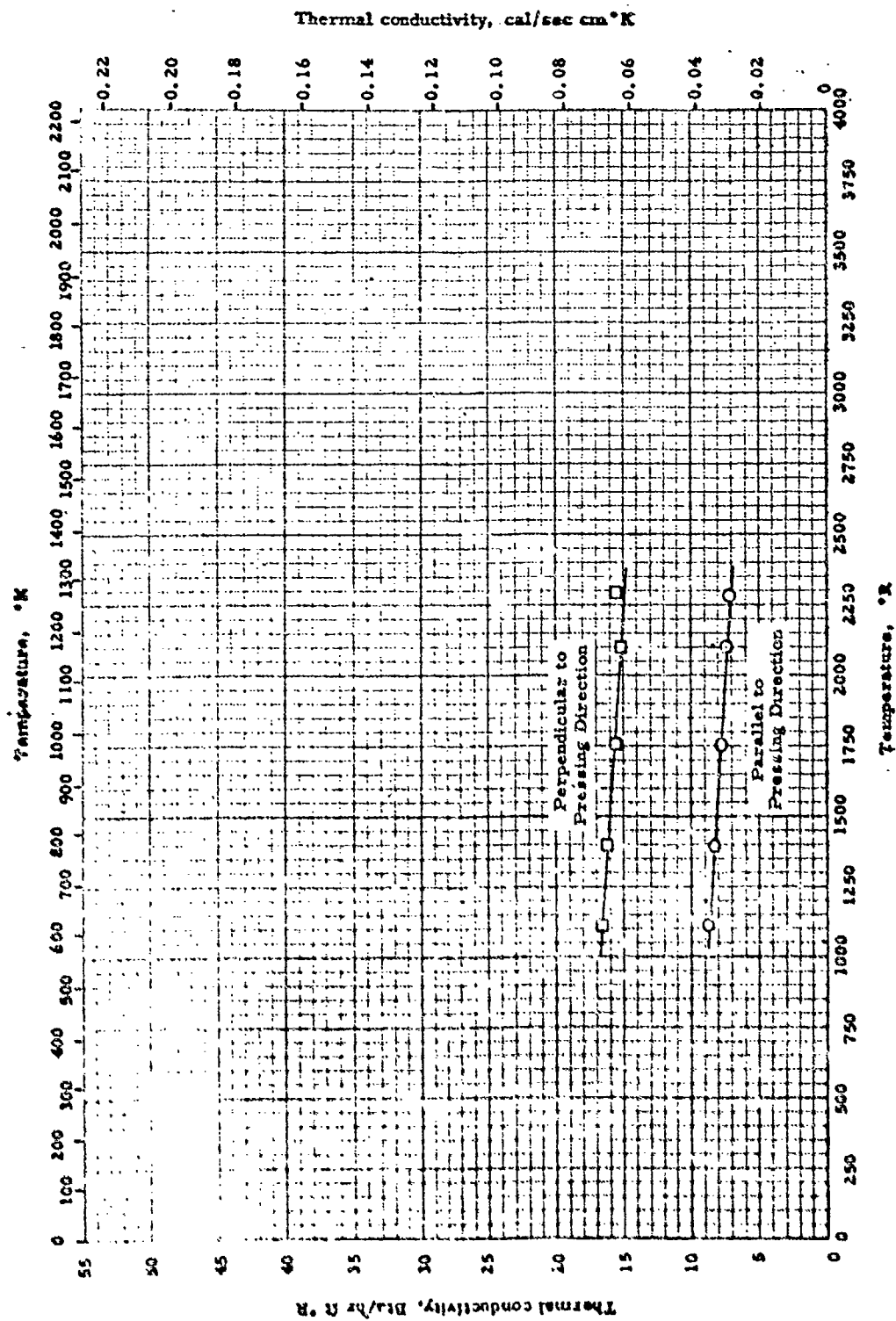
Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
0	Deveria, A. S., Salmor, D. J. and Van Arsdale, E. R.	34-116	BN 1.5% Fe as Fe_2O_3	Adiabatic calorimeter for direct measurement of C_p	

59-539

WADC TR 58-476

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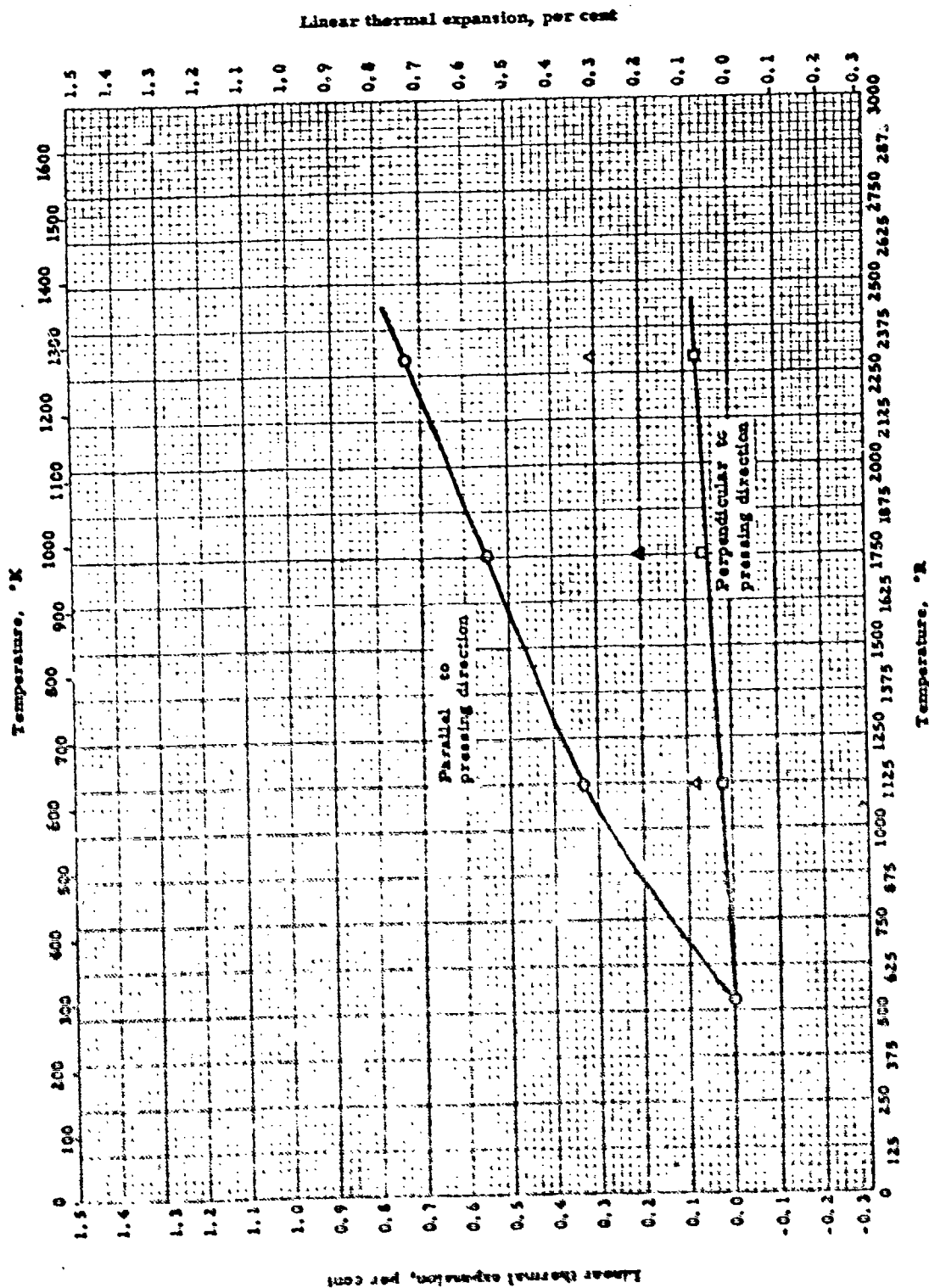


THE AMAL CONDUCTIVITY -- BORON NITRIDE

THERMAL CONDUCTIVITY -- BORON NITRIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Taylor, K. M.	55-69	1212-2292	97% BN; 2.04% B ₂ O ₃ ; 0.25% SiO ₂ ; 0.15% Al ₂ O ₃ ; 0.08% C; p = 131 lb _m /ft ²	Not given	Hot pressed; parallel to pressing direction
□	Ibid.	55-69	1212-2292	Same as above	Same as above	Hot pressed; perpendicular to pressing direction

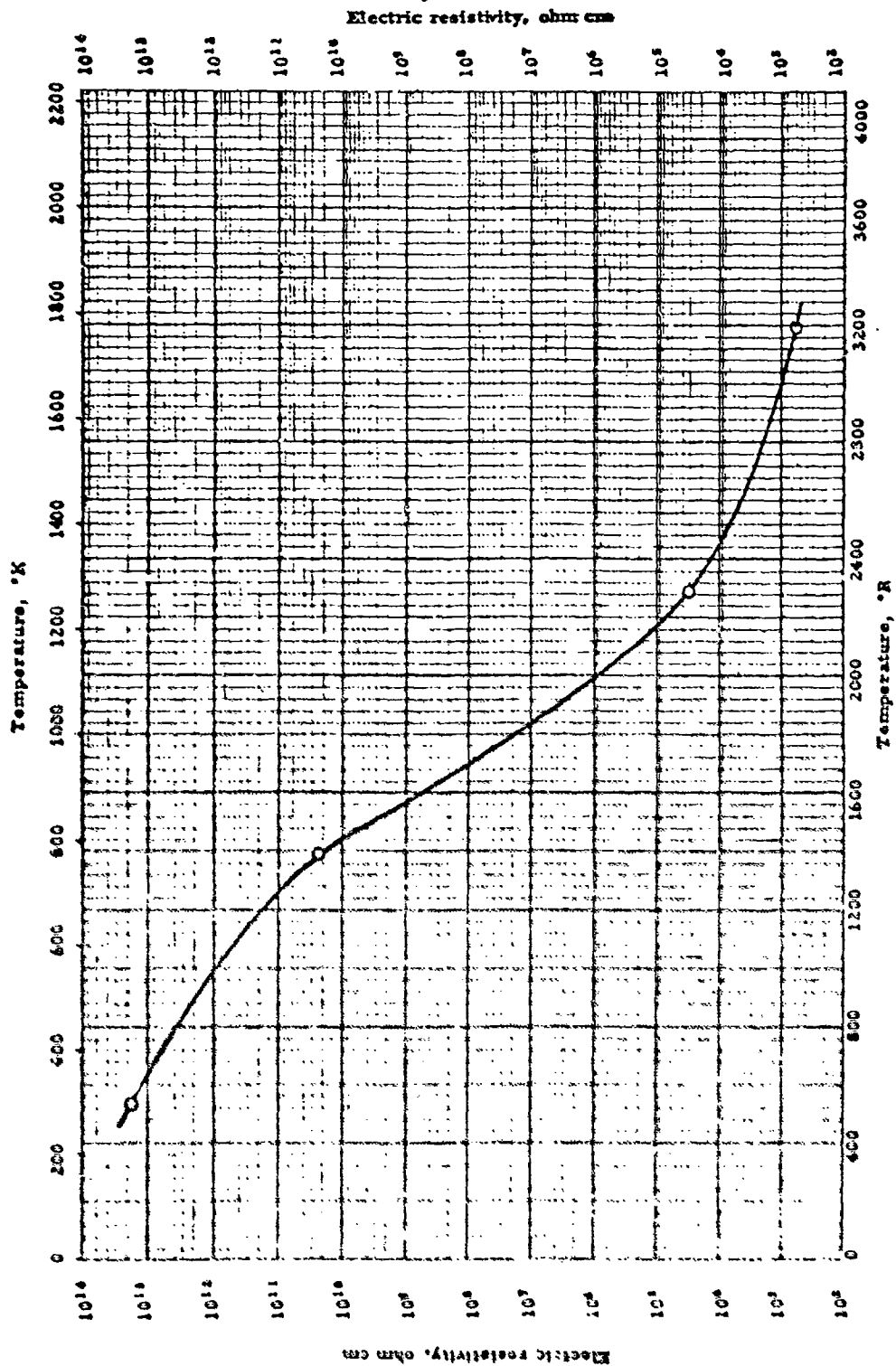


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WADC TR 58-476 965

LINEAR THERMAL EXPANSION -- BORON NITRIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
55-69	Taylor, K. M.	55-69	528-2292	97% BN; 2.04% B ₂ O ₃ ; 0.25% SiO ₂ ; 0.15% Al ₂ O ₃ ; 0.05% C. p = 132 lb _{in} /ft ²	Not given	Hot pressed. Meas. parallel to pressing direction
55-69	Id.	55-69	528-2292	Same as above	Same as above	Hot pressed. Meas. perpendicular to pressing direction
55-69	Id.	55-69	528-2292	BN. p = 107 lb _{in} /ft ²	Same as above	



ELECTRIC RESISTIVITY -- BORON NITRIDE

ELECTRIC RESISTIVITY -- BORON NITRIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Taylor, K. M.	55-69	517-3192	57% BN; 2.04% B ₂ O ₃ ; 0.25% SiO ₂ ; 0.15% Al ₂ O ₃ ; 0.08% C. Apparent $\rho = 131 \text{ lb}_m/\text{ft}^3$	Not given	Meas. with electric field parallel to pressing direction

PROPERTIES OF ALKALI METAL FLUORIDES

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point, LiF . . .	1928°R	1071°K
Heat of Fusion		
Heat of Vaporization, RbF	3622 2484-2860°R Btu/lb _m	2012 1124-1333°K cal/g
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /in ³	g/cm ³	
<u>Melting Point:</u>	°R	°K	°F
	1928	1071	348
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g	
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g	
	3622 2484-2860°R	2012 1124-1333°K	348
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g	

PROPERTIES OF ALKALI METAL FLUORIDES

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
57-174	Sense, K. A., and Sense, R. W., and Filbert Jr., R. B.	2024-2406	"Pure" LiF	Δh _v from vapor press. measurements	Supplied by Oak Ridge National Lab,
57-174	E14.	1928	RbF	MP; by thermal analysis	

PROPERTIES OF AMERICIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point.		
Heat of Fusion.		
Heat of Vaporization. . .	362 4840° R Btu/lb _m	269 2690° K cal/g
Heat of Sublimation. . . .	689 0° R Btu/lb _m	378 0° K cal/g

REPORTED VALUES

Density: lb_m/in³ g/cm³

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g
 O 362 4842° R 269 2690° K

Heat of Sublimation: Btu/lb_m cal/g
 O 676 2291° R 378 1273° K
 A 689.2 ± 0.62 0° R 377.9 ± 0.490 0° K

PROPERTIES OF AMERICIUM FLUORIDE

REFERENCE INFORMATION

Sym No.	Investigator	Ref	Range, °R	Material Composition	Test Method	Remarks
O	Carniglia, E. C.	53-73	230	99.9% pure AmF ₃	Δh_f from vapor pressure measured by Knudsen cell with radioactive counting	Precipitated from re-purified Am by aqueous HF; washed with dil HF and H ₂ O then acetone; air dried. Vapor pressure measured at 2016-2646°R
□	Ind.	53-73	48-51	Same as above	Δh_v from extrapolated vapor pressure data obtained by Knudsen cell with radioactive counting	Auth. assumed Δh_f 13 kcal/mole
△	Carniglia, E. C.	53-77	0	AmF ₃ ; 0.01% Al; 0.05% Fe	Δh_g not given	

PROPERTIES OF BERYLLIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	1937°R	1076°K
Heat of Fusion	414 1937°R Btu/lb _m	230 1076°K cal/g
Heat of Vaporization	3660 1937°R Btu/lb _m	2033 1076°K cal/g
Heat of Sublimation	4074 1937°R Btu/lb _m	2263 1076°K cal/g

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
○	1937	1076
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
○	414 1937°R	230 1076°K
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
○	3660 1937°R	2033 1076°K
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
○	4074 1937°R	2263 1076°K

PROPERTIES OF BERYLLIUM FLUORIDE

REFERENCE INFORMATION

Stm Eol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Sense, K. A., Snyder, M. J. and Gregg, J. W.	53-141	1937 1820-1937 1934-2090 1937	Beryllium fluoride, BeF ₂	MP: not given Δh _v : from vapor pres- sure measurement Δh _g : same as above Δh _f = Δh _g - Δh _v	

PROPERTIES OF PLUTONIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	3024°R	1680°K
Heat of Fusion	78.3 Btu/lb _m	43.3 cal/g
Heat of Vaporization	403 4430°R (B. P.) Btu/lb _m	223 2460 (B. P.) cal/g
Heat of Sublimation	695 0°R Btu/lb _m	386 0°K cal/g

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
Q	3024 ± 36	1680 ± 20
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
Q	78.3 3024 ± 36°R	43.3 1680 ± 20°K
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
Q	437.5 0°R	354.2 0°K
Q	400.9 4420°R (B. P.)	222.7 2440°K (B. P.)
Q	377 4590°R	209 2550°K
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
Q	695.3 0°R	386.2 0°K
Q	371 2400°R	217 1375°K
Δ	488.024 ± 0.934 0°R	382.216 ± 0.930 0°K

PROPERTIES OF PLUTONIUM FLUORIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brewer, L., Brenley, L. et al.	49-65	6-3968	PuF ₃	MF: not described here, refers to others Ah ₁ : not described here, refers to others Ah ₂ : not described here, refers to others Ah ₃ : not described here refers to others	
□	Carniglia, S. C.	53-73	2196-4590	PuF ₃ : 99.9 ± % pure 0.02% ea. Al, Mg; 0.01% La	Ah ₁ : from vapor pres- sure measured by Knudsen cell with radio- active counting Ah ₂ : from vapor pres- sure measured by Knudsen cell with radioactive counting	Precipitated with H ₂ from purified Pu (IV) stock solu- tion after reduction to Pu (III) with SO ₂ . Washed, air dried, vacuum dried, vapor press. meas. 1220- 1450°K
Δ	Carniglia, S. C. and Cunningham, B. B.	55-77	0	PuF ₃ : 0.02% ea. Al, Mg; 0.01% La	Ah ₁ : from vapor pres- sure measurements by Knudsen method	

PROPERTIES OF THORIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	2490°R	1380°K
Heat of Fusion	16 Btu/lb _m	9 cal/g
Heat of Vaporization. . .	408 _{2730°R} Btu/lb _m	226 _{1520°K} cal/g
Heat of Sublimation . . .	450 _{2120°R} Btu/lb _m	250 _{1180°K} cal/g

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point: °R °K
O 2489 1383

Heat of Fusion: Btu/lb_m cal/g
O 16_{2489°R} 9.1_{1383°K}

Heat of Vaporization: Btu/lb_m cal/g
O 408 ± 0.9_{2729°R} 226 ± 0.5_{1516°K}
O 370_{3479°R} 205_{1933°K}

Heat of Sublimation: Btu/lb_m cal/g
O 450 ± 0.5_{2117°R} 250 ± 0.3_{1176°K}
O 447_{2489°R} 249_{1383°K}

PROPERTIES OF THORIUM FLUORIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yosim, S. J. and Milne, T. A.	57-145	2489 2117-2489 2729-2679 2489	ThF ₆	AP: thermal analysis ΔH _v : from vapor press. meas. by Knudsen effusion cell. ΔH _v : from vapor press. meas. by Rodabush cell measuring total pressure ΔH _v = ΔH _g - ΔH _f	

Material Composition, %												
Symbol	ZrF ₄		NaF		RbF		LiF		Melting Point		°K	
	Mol	Wt	Mol	Wt	Mol	Wt	Mol	Wt				
										°R		
O	100	100								2148	1193	
	90.0	97.28	10	2.72						2094	1163	
	80.0	94.09	20	5.91						2015	1119	
	70.0	90.29	30	9.71						1896	1053	
	66.5	88.77	33.5	11.23						1572	873	
	62.3	86.81	37.7	13.19						1752	973	
□	55.0	82.96	45	17.04						1482	823	
	94.5	96.5			5.5	3.5				2112	1173	
	84.0	89.37			16.0	10.63				2022	1123	
	77.0	84.3			23.0	15.7				1932	1073	
	68.6	77.8			31.4	22.2				1752	973	
	64.5	74.4			35.5	25.6				1572	873	
Δ	90.0	98.31					10.0	1.69		2101	1167	
	80.0	96.26					20.0	3.74		2031	1128	
	70.6	93.94					29.4	6.06		1932	1073	
	60.0	91.48					40.0	8.52		1752	973	
	58.8	90.20					41.2	9.80		1716	953	

60-804

WADC TR 58-476

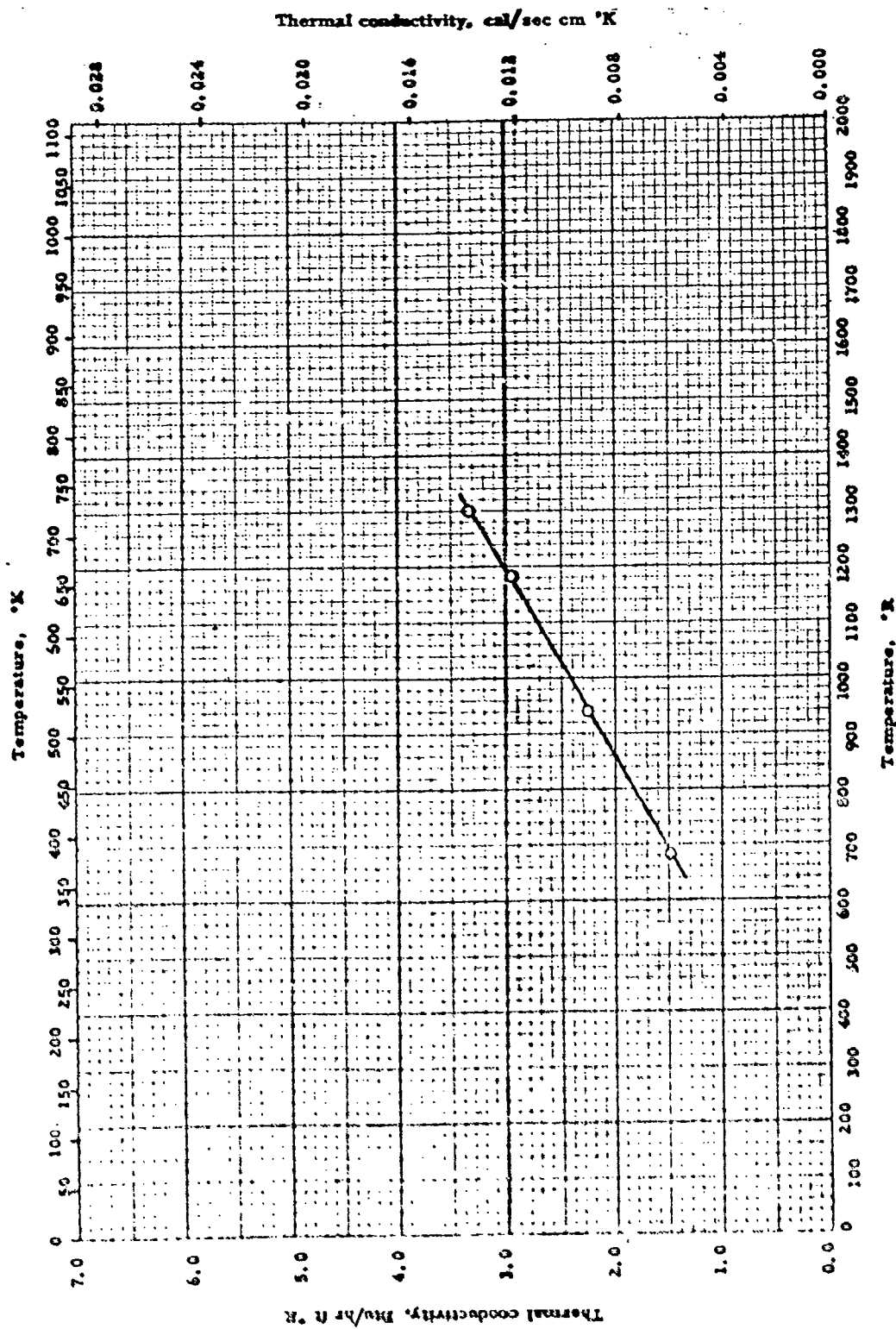
979

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MELTING POINT -- ZIRCONIUM FLUORIDE + ALKALI METAL FLUORIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
57-174	Sense, K. A. Stone, P. W. and Filbert Jr., R. B.	1482-2148	ZrF ₄ + NaF (82.96-100% ZrF ₄)	MP; from vapor press. meas. and thermal analysis	
57-174	Idid.	1572-2148	ZrF ₄ + RbF (74.4-96.5% ZrF ₄)	MP; same as above	
57-174	Idid.	1716-2148	ZrF ₄ + LiF (90.20-98.31% ZrF ₄)	MP; same as above	
57-174	Idid.	2148	100% ZrF ₄	MP; same as above	

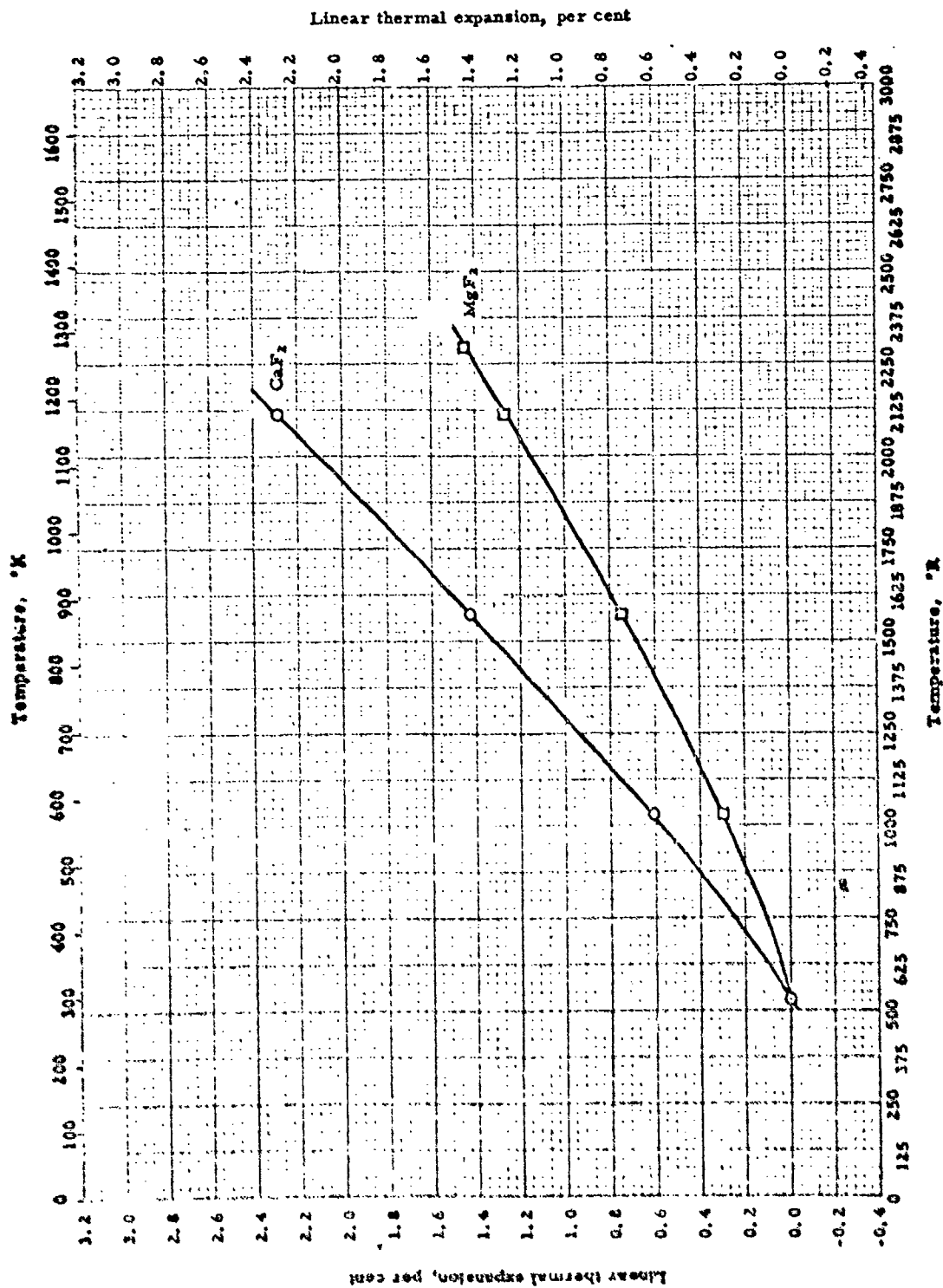


Thermal conductivity -- LITHIUM FLUORIDE

THERMAL CONDUCTIVITY -- LITHIUM FLUORIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Knaep, W. J.	43-11	681-1300	Lithium Fluoride	Axial heat flow in rod, guarded heat source and sample, by Chromel-Const. thermocouples	Synthetic material

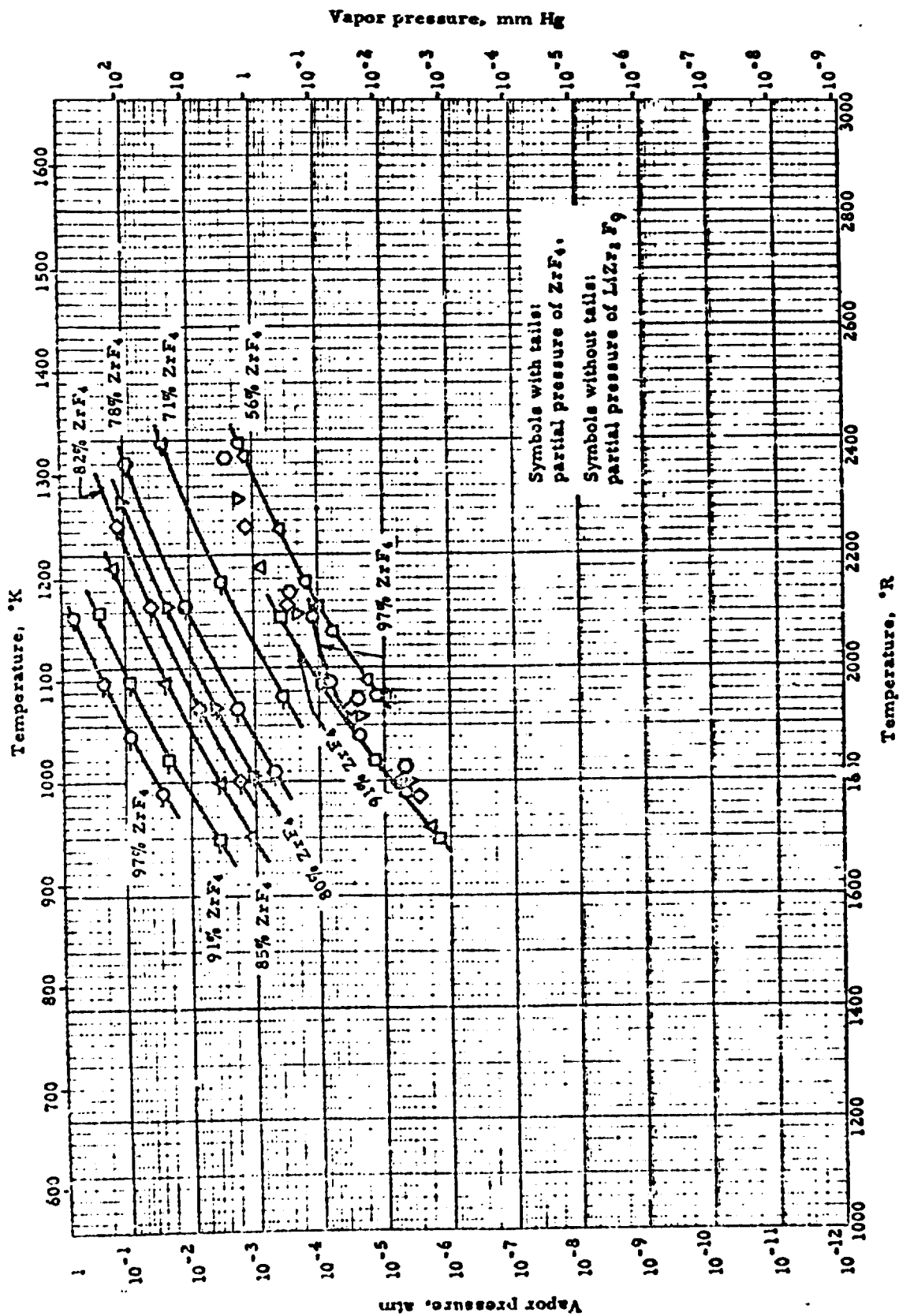


LINEAR THERMAL EXPANSION -- FLUORIDES

LINEAR THERMAL EXPANSION -- FLUORIDES

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. H.	56-7	1032-2112	CaF ₂	Dilatometer. Temp. by Pt thermocouple	Sintered, high density
□	D/A.	56-7	1032-2292	MgF ₂	Same as above	Fine grain

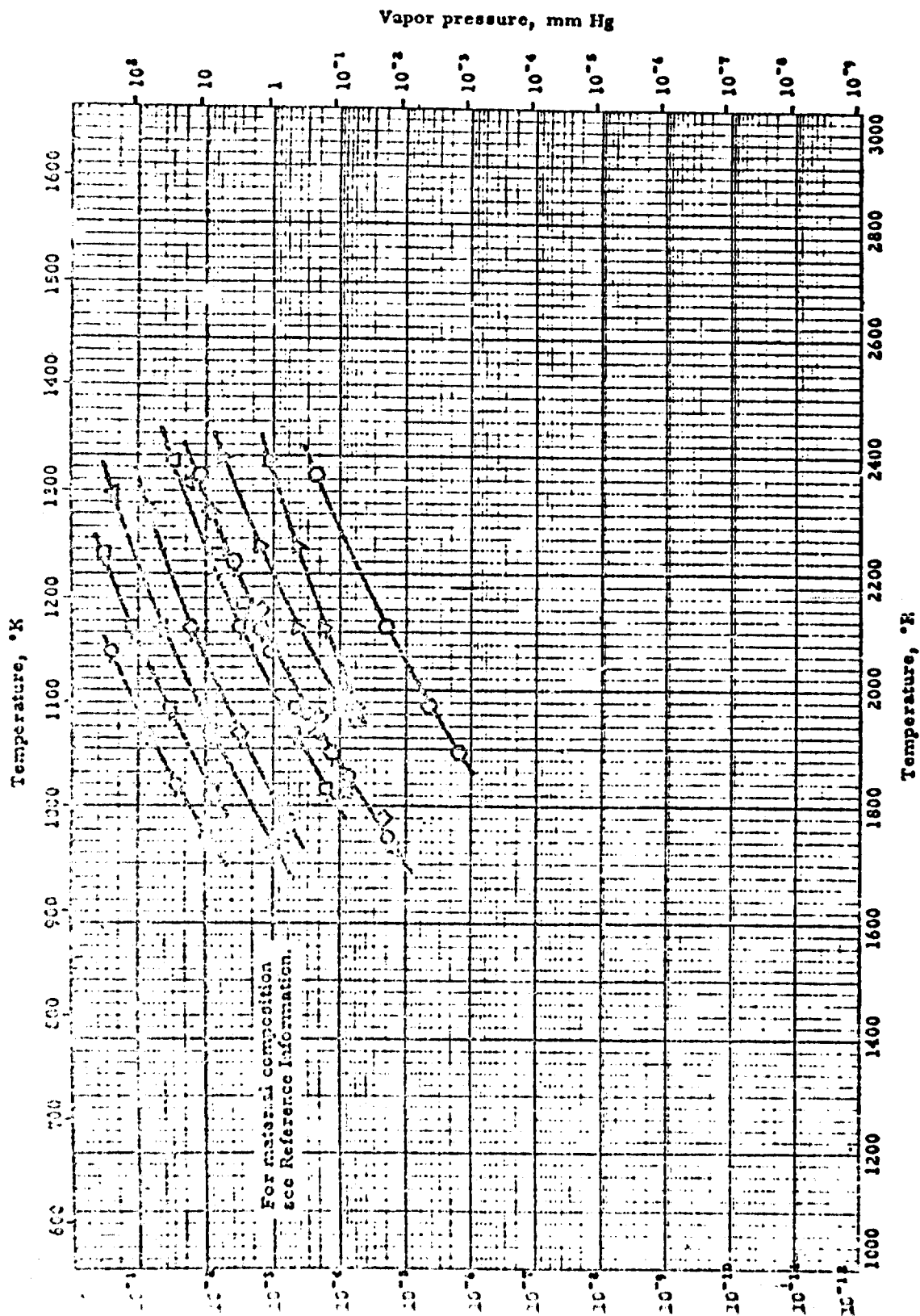


VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + LITHIUM FLUORIDE

VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + LITHIUM FLUORIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Sears, R. A., Stone, E. W. and Filbert Jr., R. B.	57-176	1782-2093	96.7% ZrF ₄ (82 mol%)	Rate of weight loss to inert gas stream over sample	Data from least - square Eqn. Auth. est. accuracy + 8%. Auth. believe vapor consists of LiF, ZrF ₄ and LiZrF ₅ Symbol with tall partial pressure of ZrF ₄ Symbol without tall partial pres- sure of LiZrF ₅
□	D14.	57-176	1697-2097	91.3% ZrF ₄ (61.8 mol%)	Same as above	Same as above
△	D14.	57-176	1706-2122	85.4% ZrF ₄ (47.5 mol%)	Same as above	Same as above
◇	D14.	57-176	1850-2250	82.4% ZrF ₄ (42.1 mol%)	Same as above	Same as above
▽	D14.	57-176	1859-2285	80.4% ZrF ₄ (38.8 mol%)	Same as above	Same as above
○	D14.	57-176	1812-2369	77.8% ZrF ₄ (35.2 mol%)	Same as above	Same as above
□	D14.	57-176	1957-2396	70.8% ZrF ₄ (27.3 mol%)	Same as above	Same as above
□	D14.	57-176	1982-2396	55.7% ZrF ₄ (16.3 mol%)	Same as above	Same as above

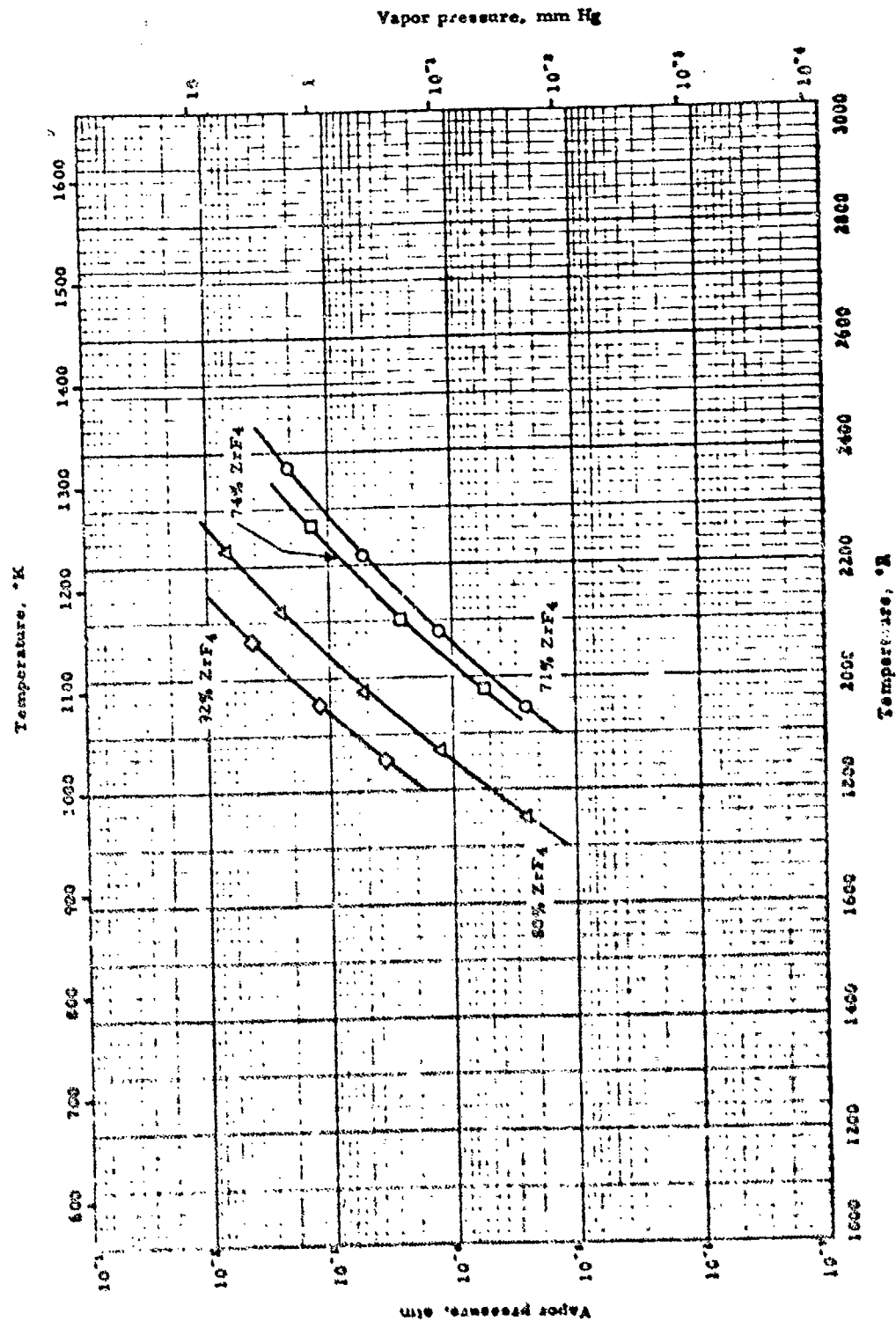


VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + RUBIDIUM FLUORIDE

VAPOR PRESSURE -- ZIRCONIUM FLUORIDE-RUBIDIUM FLUORIDE

REFERENCE INFORMATION

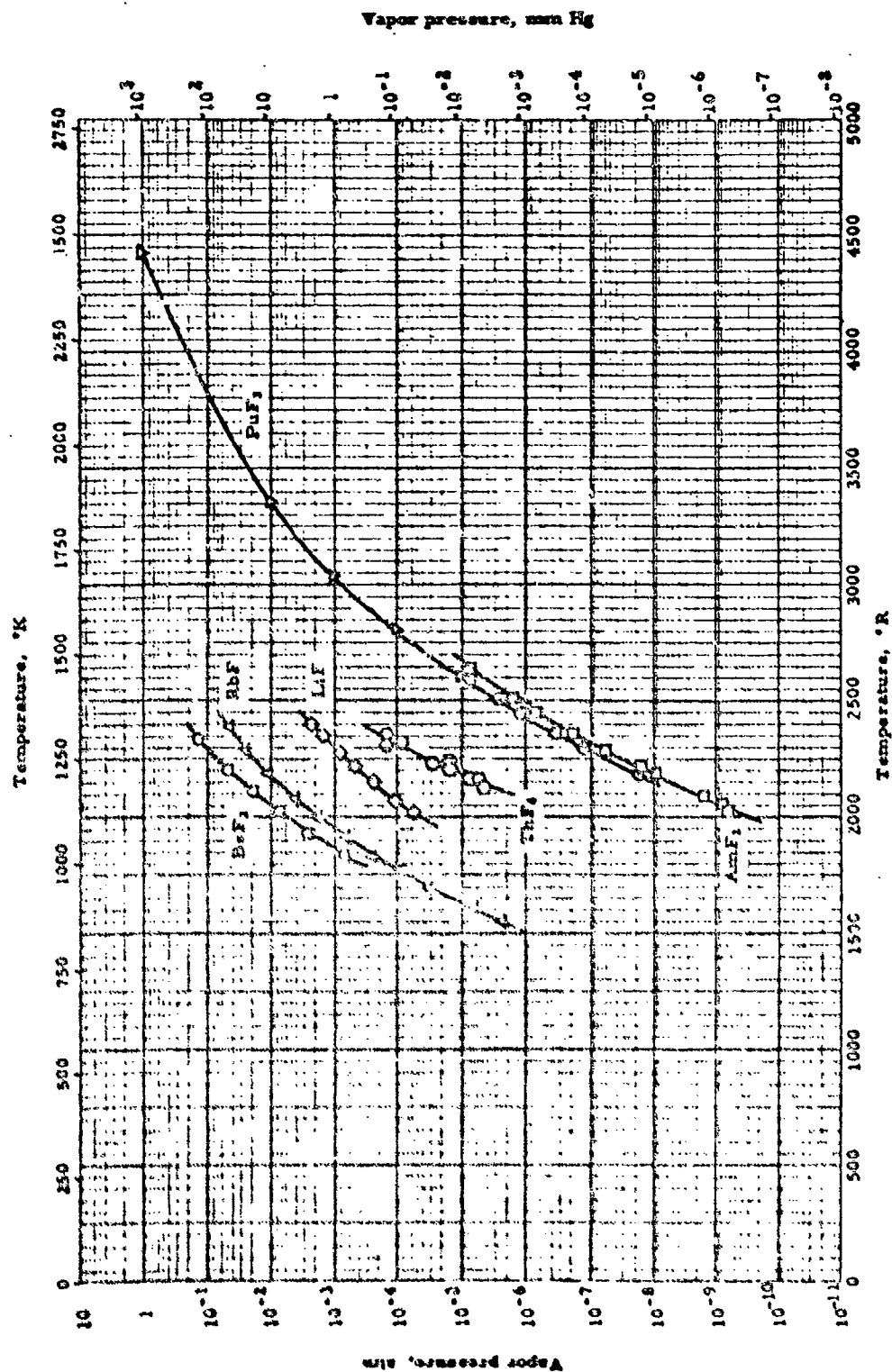
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O. L. Stone, R. W. Stone, R. B. Stone	57-174	1742-2068	31.2% ZrF ₄ , Made from "pure salts"	Rate of weight loss to inert gas stream over sample	Data from least square eqn. Auth. believe vapor consists of RbF, ZrF ₄ and RbZr ₂ F ₆ . Symbol with tail; partial pressure of ZrF ₄ . Symbol without tail; partial pressure of RbZr ₂ F ₆ . Same as above
□ D. L.	57-174	1832-2236	75.0% ZrF ₄	Same as above	Same as above
△ D. L.	57-174	1733-2138	66.9% ZrF ₄	Same as above	Same as above
◇ D. L.	57-174	1780-2300	50.6% ZrF ₄	Same as above	Same as above
▽ D. L.	57-174	1778-2450	51.1% ZrF ₄	Same as above	Same as above
○ D. L.	57-174	1894-2369	34.2% ZrF ₄	Same as above	Same as above except symbol with tail; partial pressure of RbF
○ D. L.	57-174	1836-2400	22.1% ZrF ₄	Same as above	Same as above



VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + SODIUM FLUORIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
1	Jones, K. A., and Silbert Jr., R. B.	57-174	1940-220.9	70.9% ZrF ₄ (33.6 mol %)	Rate of weight loss to inert gas stream over sample.	From least-squares eq. fitted by auth. with max. deviation of 8% at lowest temp; partial press. of NaF derived on basis that vapor consists only of NaF and ZrF ₄
2	ibid.	57-174	1970-226.6	74.2% ZrF ₄ (41.9 mol %)	Same as above	Same as above
3	ibid.	57-174	1955-222.3	79.9% ZrF ₄ (50.0 mol %)	Same as above	Same as above
4	ibid.	57-174	1856-206.1	91.9% ZrF ₄ (74.0 mol %)	Same as above	Same as above



VAPOR PRESSURE -- FLUORIDES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Carliglio, S. C. and Cunningham, B. B.	55-77 also 53-73	2188-2599	PuF_3 , 0.02% ea. Al, Mg; 0.01% La	Knudsen effusion cell of tantalum, Temp. meas. by Pt, Pt-Rh thermocouple	Thermocouple calibrated against MP of Au, Ag, Sn, Al, Auth. est. accuracy $\pm 5\%$
Q	Ibid.	55-77 53-73	2027-2644	AmF_3 , 0.05% Fe; 0.01% Al	Same as above	Same as above
Δ	Grase, K. A., Gunn, R. W. and Fisher Jr., R. B.	57-174	1552-2398	RbF "pure salt"	Meas. rate of deposit of salt from inert gas flow over sample	By Oak Ridge National Laboratory, Least-square eq. was fitted to ex- perimental data by authors with $\pm 8\%$ deviation at the lowest temper- atures
Q	Ibid.	57-174	2023-2400	LaF "pure salt"	Same as above	Same as above
▽	Brumer, L., Bremley, L., et al	49-65	2484-4423	PuF_3	Not described here, refers to others	
Q	Yocum, S. J. and Mills, T. A.	57-164	2030-2360	TbF_4 , 40.2% ea. O_2 or H_2O ; 74.8% Th (compared with 75.5% theoretical)	Knudsen effusion cell of nick- el. Temp. meas. by calibrated Pt, Pt-Rh thermocouple	Auth. state data are tentative. Auth. report: $\log_{10} p \text{ (atm)} = 10.51 - \frac{18740}{T^\circ K}$
Q	Sensen, K. A., Snyder, M. J. and Clapp, J. W.	53-141 also 57-77	1842-2337	Beryllium fluoride	Meas. rate of condensation of vapor	Corrected for diffusion

<u>Symbol</u>	<u>Material Composition</u>	<u>Density</u>	
		<u>lb /ft³_m</u>	<u>g/cm³</u>
O	CeBr ₃	323	5.18
□	LaBr ₃	254	4.07
Δ	PrBr ₃	328	5.26

DENSITY -- RARE EARTH BROMIDES

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Zachariasen, W. H.	49-66	Room	CeBr ₃	ρ : computed from x-ray measurements of lattice	
□	Ibid.	49-66	Room	LaBr ₃	Same as above	
1		49-66	Room	PrBr ₃	Same as above	

PROPERTIES OF BROMIDES OF URANIUM AND TRANSURANIC ELEMENTS

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	1717 °R	954 °K
Heat of Fusion	50.1 Btu/lb _m	27.8 cal/g
Heat of Vaporization. . .	160 _{3213 °R(B.P.)} Btu/lb _m	91 _{1785 °K(B.P.)} cal/g
Heat of Sublimation . . .	307 _{°R} Btu/lb _m	170 _{°K} cal/g

* Values for PuBr₃; for others see Reported Values below.

REPORTED VALUES

			Material
<u>Density:</u>	lb _m /ft ³	g/cm ³	
O	413	6.61	Np Br ₃
□	408	6.53	U Br ₃
<u>Melting Point:</u>	°R	°K	
Δ	1717	954	Pu Br ₃
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g	
Δ	50.1 _{1717 °R}	27.8 _{954 °K}	Pu Br ₃
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g	
Δ	271 _{°R}	151 _{°R}	Pu Br ₃
Δ	160 _{3213 °R}	91 _{1785 °K}	
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g	
Δ	307 _{°R}	170 _{°K}	Pu Br ₃

PROPERTIES OF BROMIDES OF URANIUM AND TRANSURANIC ELEMENTS

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °C	Material Composition	Test Method	Remarks
0	Zachariasen, W. H.	40-66		NpBr ₃	p: computed from x-ray measurements of lattice	
□	Ibid.	49-66		UBr ₃	p: same as above	
Δ	Brewer, L., Bromley, L. and Loigren, N. L.	49-65	1717	PuBr ₃	MP: not described here, refers to others	
			1717		Δh: not described here, refers to others	
			0 and 321.5		Δh: not described here, refers to others	
			0		Δh: not described here, refers to others	

<u>Symbol</u>	<u>Material Composition</u>	<u>Density</u>	
		<u>lb m³/ft³</u>	<u>g/cm³</u>
○	CeCl ₃	247	3.95
□	LaCl ₃	240	3.84
△	NdCl ₃	258	4.14
◇	PrCl ₃	251	4.02

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DENSITY -- RARE EARTH CHLORIDES

DENSITY -- BARE EARTH CHLORIDES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Com. oxidn	Test Method	Remarks
○	Zachariasen, W. H.	49-46	Room	CeCl ₃	p: computed from x-ray measurements of lattice p: same as above	
□	Ind.	49-46	Room	LaCl ₃	p: same as above	
△	Ind.	49-46	Room	NdCl ₃	p: same as above	
◇	Ind.	49-46	Room	PrCl ₃	p: same as above	

PROPERTIES OF THORIUM CHLORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	287 lb _m /ft ³	4.60 g/cm ³
Melting Point.	1967°R*	1093°R*
Heat of Fusion		
Heat of Vaporisation. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics, Ref. 59-2

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	287	4.60

<u>Melting Point:</u>	°R	°K
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Heat of Fusion:	Btu/lb _m	cal/g

Heat of Vaporization: $\frac{\text{Btu/lb}}{\text{m}}$ cal/gHeat of Sublimation: 34.4 kcal/g

PROPERTIES OF THORIUM CHLORIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Zachariasen, W. H.	49-64		ThCl ₄	p: computed from x-ray meas. of lattice	

PROPERTIES OF CHLORIDES OF URANIUM AND TRANSURANIC ELEMENTS

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density	356 lb _m /ft ³	5.70 g/cm ³
Melting Point	1860°R	1033°K
Heat of Fusion	78.5 Btu/lb _m	43.6 cal/g
Heat of Vaporization	241.5 Btu/lb _m	134.2 cal/g
Heat of Sublimation	435.8 ₀ °R Btu/lb _m	242.1 ₀ °K cal/g

* Values for PuCl₃; for others see Reported Values below

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³	Material
○	344	5.51	UCl ₃
□	384	4.87	UCl ₄
△	348	5.58	NpCl ₃
◇	387	4.92	NpCl ₄
▽	356	5.70	PuCl ₃

<u>Melting Point:</u>	°R	°K	
○	1860 ± 9	1033 ± 5	PuCl ₃

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g	
○	78.5	43.6	PuCl ₃

<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g	
○	363.0 ₀ °R	204.4 ₀ °K	PuCl ₃
○	241.5 ₁₆₇₂ °R (B.P.)	134.2 ₂₀₁₀ °K (B.P.)	PuCl ₄

<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g	
○	435.8 ₀ °R	242.1 ₀ °K	PuCl ₃

PROPERTIES OF CHLORIDES OF URANIUM AND TRANSURANIC ELEMENTS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zachariasen, W. K.	49-66	Room	UCl ₃	pi computed from x-ray measurements of lattice	
□	Ibid.	49-66	Room	UCl ₄	p: same as above	
△	Ibid.	49-66	Room	NpCl ₃	pi same as above	
◇	Ibid.	49-66	Room	NpCl ₄	p: same as above	
▽	Ibid.	49-66	Room	PuCl ₃	p: same as above	
○	Brewer, L., et al	49-65	0-3672	PuCl ₃	MP: not given; refers to others Δ _h : not given; refers to others Δ _h : not given; refers to others Δ _h : not given; refers to others Δ _h : not given; refers to others	

PROPERTIES OF PLUTONIUM IODIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point.	1890°R	1050°K
Heat of Fusion	34.7 Btu/lb _m	19.3 cal/g
Heat of Vaporization. . .	115 _{2970°R (B.P.)} Btu/lb _m	63.8 _{1650°K (B.P.)} cal/g
Heat of Sublimation . . .	201 _{0°R}	111 _{0°K}

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
<u>Melting Point:</u>	°R	°K
○	1890	1050
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
○	34.7 _{1890°R}	19.3 _{1050°K}
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
○	172.0 _{0°R}	95.5 _{0°K}
○	114.8 _{2970°R}	63.8 _{1650°K}
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
○	200.6 _{0°R}	111 _{0°K}

PROPERTIES OF PLUTONIUM IODIDE

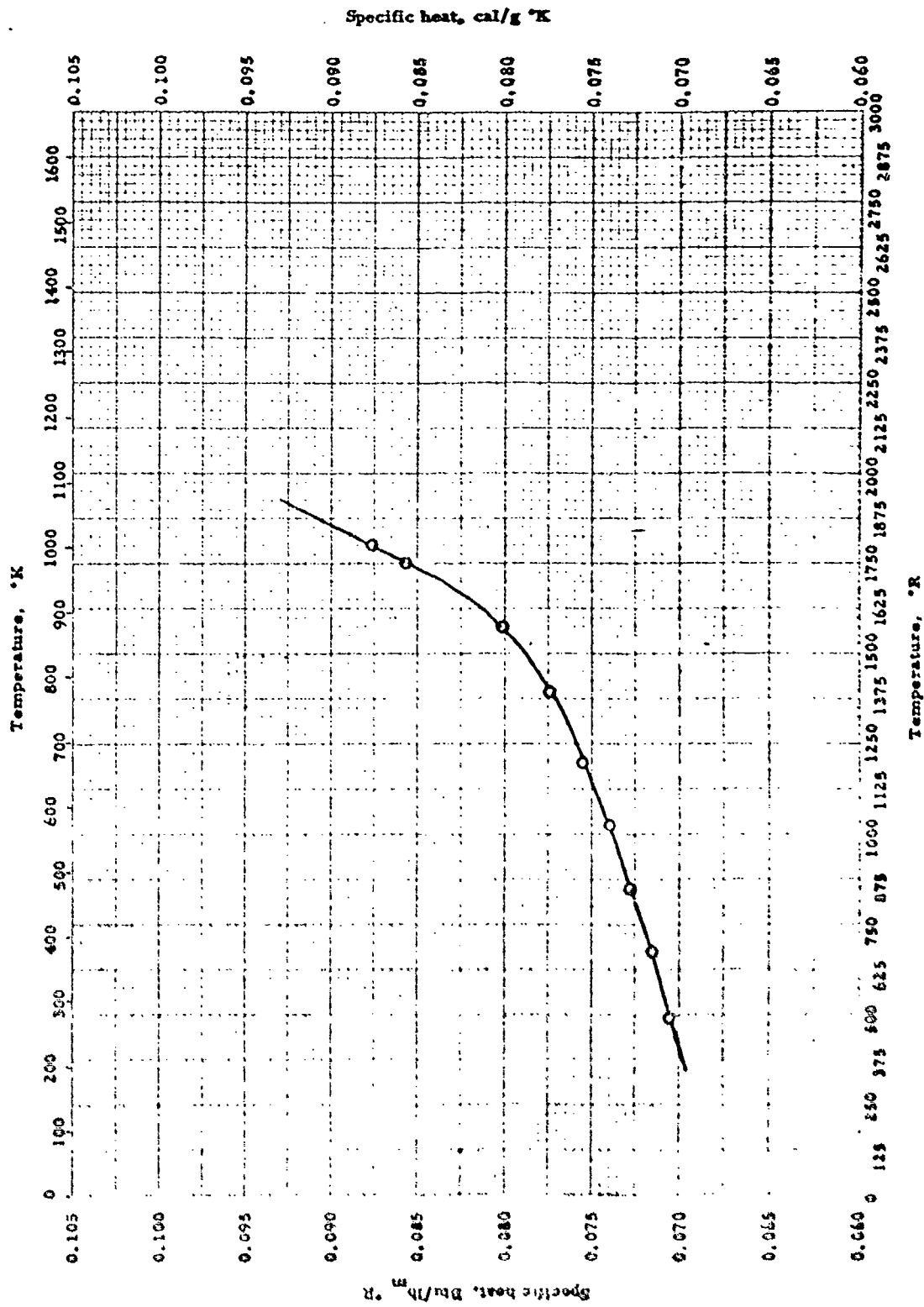
REFERENCE INFORMATION

Sym b.i.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brewer, L., et al	49-65	0-2970	PuI ₂	MP; not given; refers to other ref. ΔH _f ; not given; refers to other ref. ΔH _v ; not given; refers to other ref. ΔH _g ; not given; refers to other ref.	

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SPECIFIC HEAT -- URANIUM CHLORIDE

SPECIFIC HEAT -- URANIUM CHLORIDE

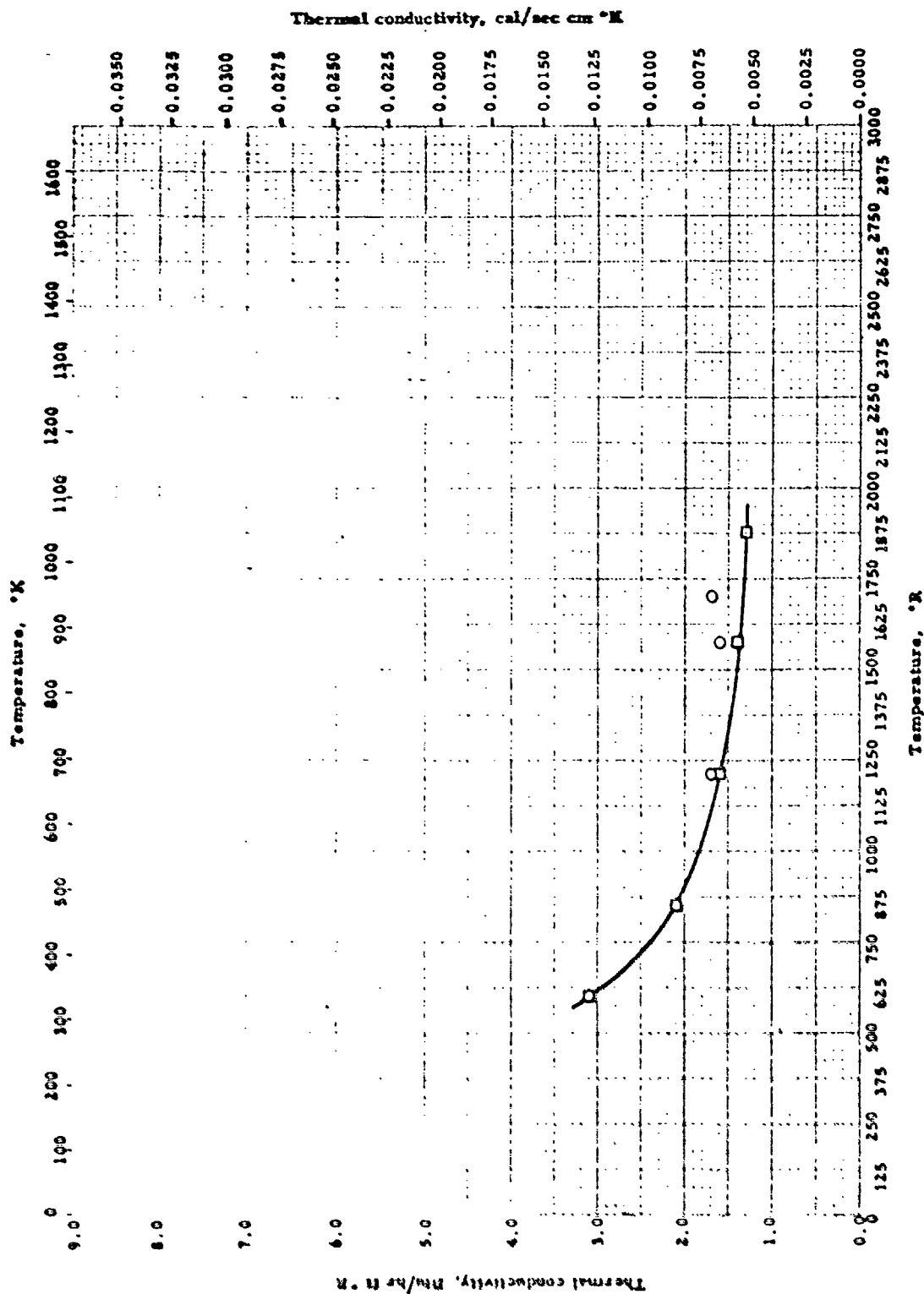
REFERENCE INFORMATION

O	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ginsburg, D. C. and Corruccini, R. J.	47-1	492-1792	99.5% UCl ₄ , 0.02% Na, 0.013% Fe, 0.01% Ca, 0.01% Mg, 0.006% Si; balance U (probably as oxide)	Drop method; ice calorimeter	

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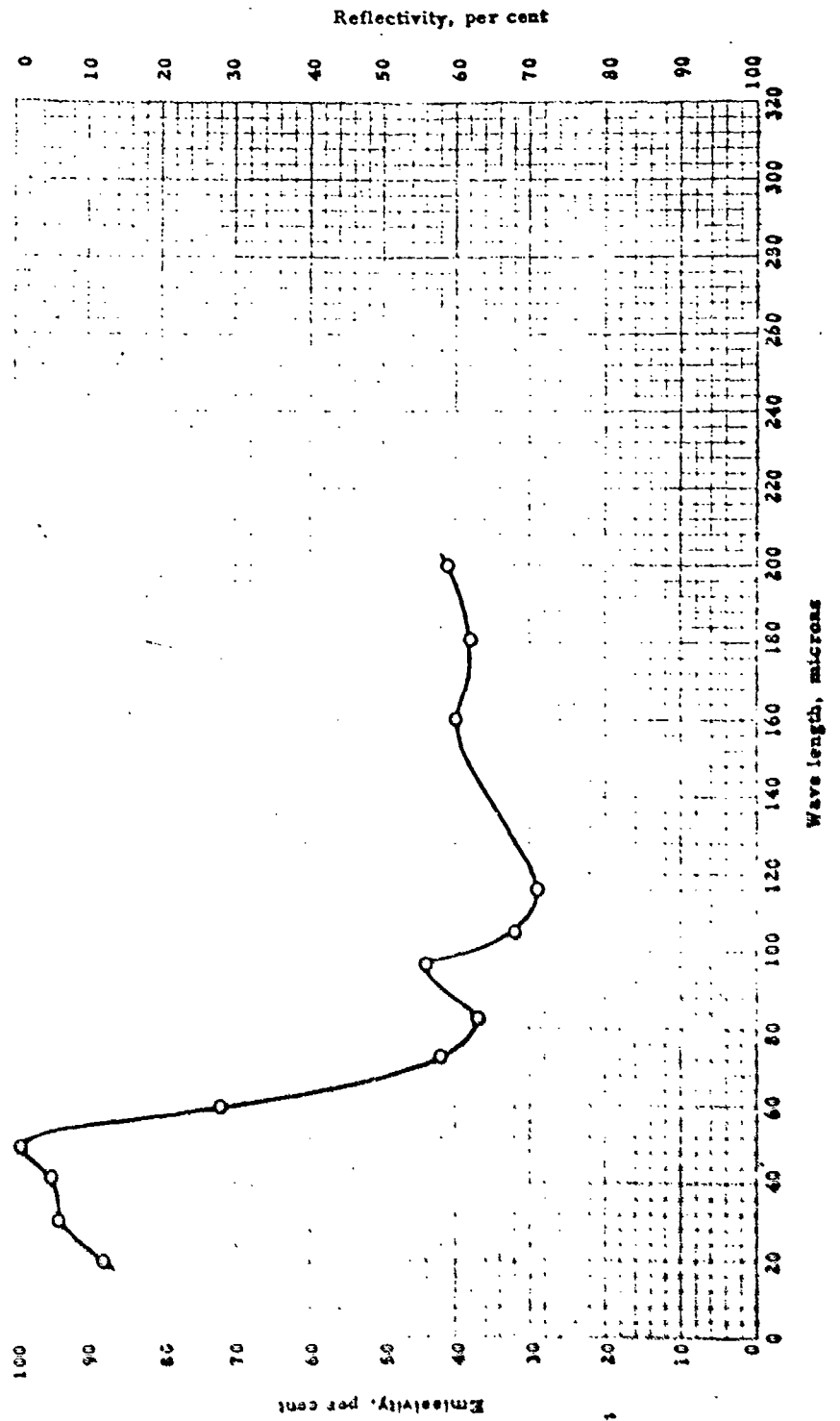
Thermal conductivity -- FLUORITE

THERMAL CONDUCTIVITY -- FLUORITE

REFERENCE INFORMATION

<u>Sym</u> <u>bol</u>	<u>Investigator</u>	<u>Ref.</u>	<u>Range, °R</u>	<u>Material Composition</u>	<u>Test Method</u>	<u>Remarks</u>
<input type="radio"/>	Charvat, F. E. and Kingsery, W. D.	57-53	582-1932	Single crystal CaF_2	Comparative; rods	Data corrected to zero porosity. Porosity is 8.17% based on density and 10.9% based on microstructure
<input type="checkbox"/>	Ibid.	57-53	582-1932	Polycrystalline CaF_2	Same as above	

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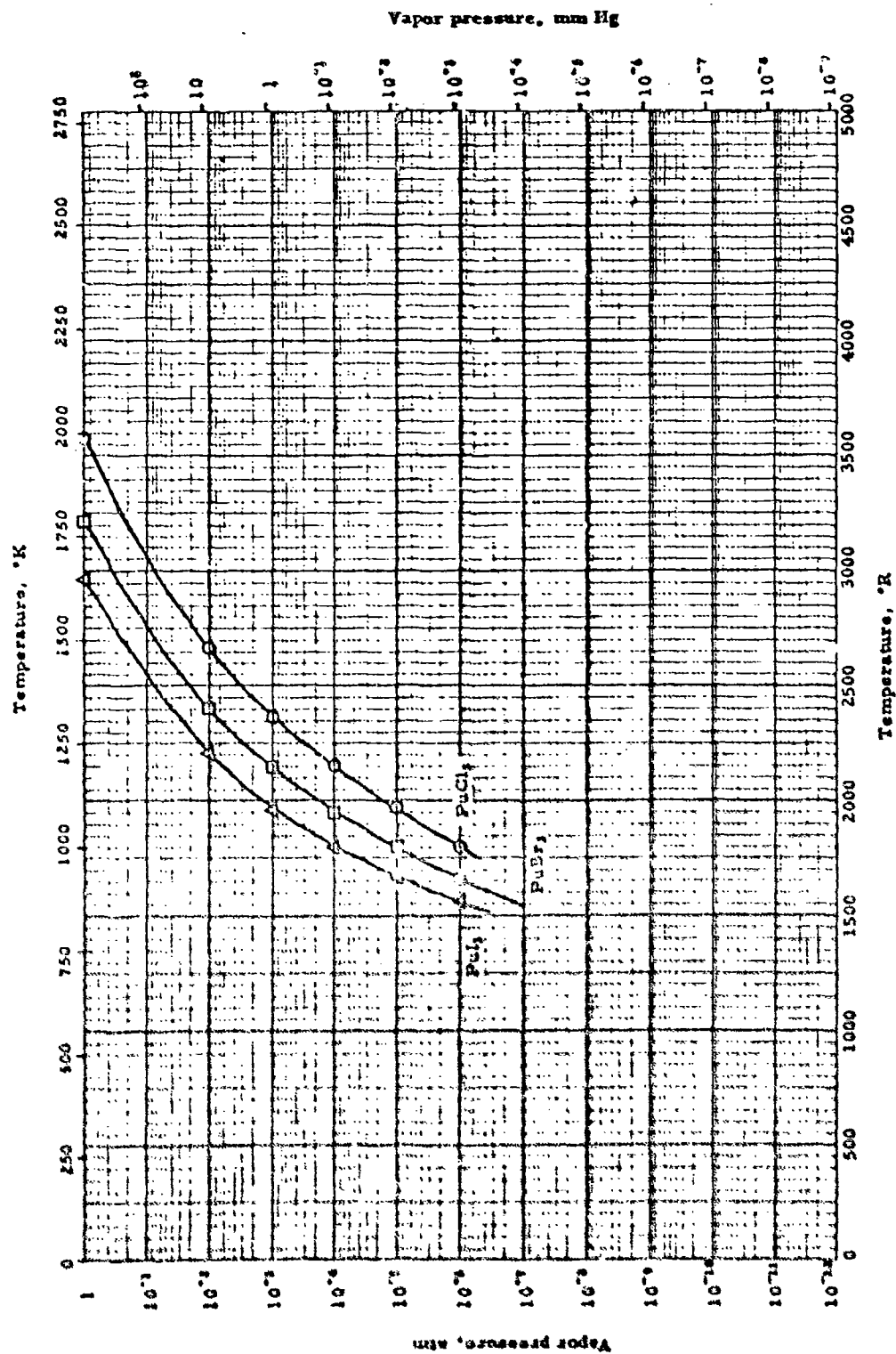


SPECTRAL EMISSIVITY -- THALLIUM CHLORIDE

SPECTRAL EMISSIVITY -- THALLIUM CHLORIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yoshinaga, H.	55-96	533	TlCl	Spectral normal reflectivity; far infrared spectrograph	Probably fairly pure crystals



VAPOR PRESSURE -- PLUTONIUM HALIDES

VAPOR PRESSURE -- PLUTONIUM HALIDES

REFERENCE INFORMATION

Δ	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L. et al.	49-65	1800-3572	PuCl ₃	Not given here, refers to others	
□	Ind.	49-65	1665-3213	PuBr ₃	Same as above	
△	Ind.	49-65	1557-2970	PuI ₃	Same as above	Estimated from correspond- ing uranium compound

PROPERTIES OF BERYLLIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	260 lb _m /ft ³	4.2 g/cm ³
Melting Point.	4452°R	2473°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	260	4.2

<u>Melting Point:</u>	°R	°K
Q	4452 ±	2473 ±

Heat of Fusion:

Heat of Vaporization:	Btu/lb _m	cal/g

Heat of Sublimation: mJ/g mJ/g cal/g

PROPERTIES OF BERYLLIUM SULFIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Brewer, L., Bromley, L. et al.	48-51	Room 4452	BeS, "Pure"	p: not described here, refers to others MP: not described here, refers to others	White sample

PROPERTIES OF CERIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	370 lb _m /ft ³ *	5.93 g/cm ³ *
Melting Point.	4900°R *	2725°K *
Heat of Fusion		
Heat of Vaporization.		
Heat of Sublimation		

*Value for CeS₂; for others see Reported Values below

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³	Material
O	370	5.93	CeS
Δ	332	5.3	Ce ₃ S ₄
○	325	5.2	Ce ₂ S ₃

<u>Melting Point:</u>	°R	°K	Material
O	4902 ± 180	2723 ± 100	CeS
□	4091 ± 135	2273 ± 75	CeS _{1.15}
Δ	4182 ± 135	2323 ± 75	Ce ₃ S ₄
○	3894 ± 90	2163 ± 50	Ce ₂ S ₃

<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF CERIUM SULFIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Eastman, E. D., Brewer, L. et al.	50-27 also 48-31	4722-5082	CeS	MP: visual observation; optical pyrometer pi not given	p measured by Zachariasen at ANL
2	Ibid.	50-27 also 48-31	3956-4226	CeS _{1.15} (Eutectic)	MP: same as above	
3	Ibid.	50-27 also 48-31	4047-4317	Ce ₃ S ₄	MP: same as above pi not given	Same as above
4	Ibid.	50-27 also 48-31	3804-3994	Ce ₂ S ₃	MP: same as above pi same as above	Same as above

PROPERTIES OF MOLYBDENUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density		
Melting Point	3500°R	1920°K
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

REPORTED VALUES

Density: lb_m/ft³ g/cm³

Melting Point:	°R	°K
○	3507 ± 45	1923 ± 25

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: 244 lb cu gal/g

list of Submissions 2/14/10 cal/s

PROPERTIES OF MOLYBDENUM SULFIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Zel'dman, A. M. and Belyavskaya, L. V.	56-151	3462-3558	MoS ₂ (Molybdenite), Initial com- pos. of MoS ₂ : 58.45% Mo; 39.02% S At 1650°C: 60.48% Mo; 37.7% S At 1700°C: 70.24% Mo; 31.8%	MP: not given	Heated in press to 1600- 1900°C. Products studied microscopically, chemical- ly, and by x-ray analysis. Melts with decomposition at 1650-1700°C

PROPERTIES OF THORIUM SULFIDE

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density.	460 lb _m /ft ³	7.36 g/cm ³
Melting Point	3921 °R	2178 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Values for ThS₂; for others see Reported Values below.

REPORTED VALUES

<u>Density:</u>		lb _m /ft ³	g/cm ³	Material
	○	597	9.56	ThS
	◇	486	7.78	Th ₄ S ₇ or Th ₇ S ₁₂
	○	460	7.36	ThS ₂
<u>Melting Point:</u>		°R	°K	
	○	4452 ±	2473 ±	ThS
	□	3732 ±	2073 ±	ThS-Th ₂ S ₃ eutectic
	△	4002 ± 90	2223 ± 50	Th ₂ S ₃
	◇	3678	2043	Th ₄ S ₇ or Th ₇ S ₁₂
	▽	3670 ± 45	2038 ± 25	Th ₂ S ₃ -ThS ₂ eutectic
	○	3921	2178	ThS ₂
<u>Heat of Fusion:</u>		Btu/lb _m	cal/g	
<u>Heat of Vaporization:</u>		Btu/lb _m	cal/g	
<u>Heat of Sublimation:</u>		Btu/lb _m	cal/g	

PROPERTIES OF THORIUM SULFIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
0	Brewer, L., Bromley, L., et al.	48-31	4432	ThS	p: not described here, refers to others MP: not described here, refers to others	Silvery metallic lustre
1	Idid.	48-31	3732	Eutectic between ThS and Th ₂ S ₃	MP: same as above	
2	Idid.	48-31	3912-4092	Th ₂ S ₃	MP: same as above	Brown
3	Idid.	48-31	3678	"Th ₂ S ₃ or Th ₂ S ₁₃ "	p: same as above MP: same as above	
4	Idid.	48-31	3625-3715	Eutectic between "Th ₂ S ₃ or Th ₂ S ₁₃ " and ThS ₂	MP: same as above	
5	Idid.	48-31	3921	ThS ₂	p: same as above MP: same as above	Purple

PROPERTIES OF URANIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	493 lb _m /ft ³ *	7.90 g/cm ³ *
Melting Point.		
Heat of Fusion		
Heat of Vaporization.		
Heat of Sublimation		

* Value for US₈; for others see Reported Values below.

REPORTED VALUES

Density:	lb _m /ft ³	g/cm ³	Material
O	678.6	10.87	US
U	493	7.90	US ₂

Melting Point:	°R	°K
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Heat of Fusion:	Btu/lb _m	cal/g
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Heat of Vaporization:	Btu/lb _m	cal/g
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Heat of Sublimation:	Btu/lb _m	cal/g
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PROPERTIES OF URANIUM SULFIDE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
48-31	Brewer, L. Dromley, L. et al.	Room	US	p: not described here, refers to others	US ₂ is black
48-31	Ibid.	Room	US ₂	p: same as above	

WADSWORTH

1021

9 - D - 6

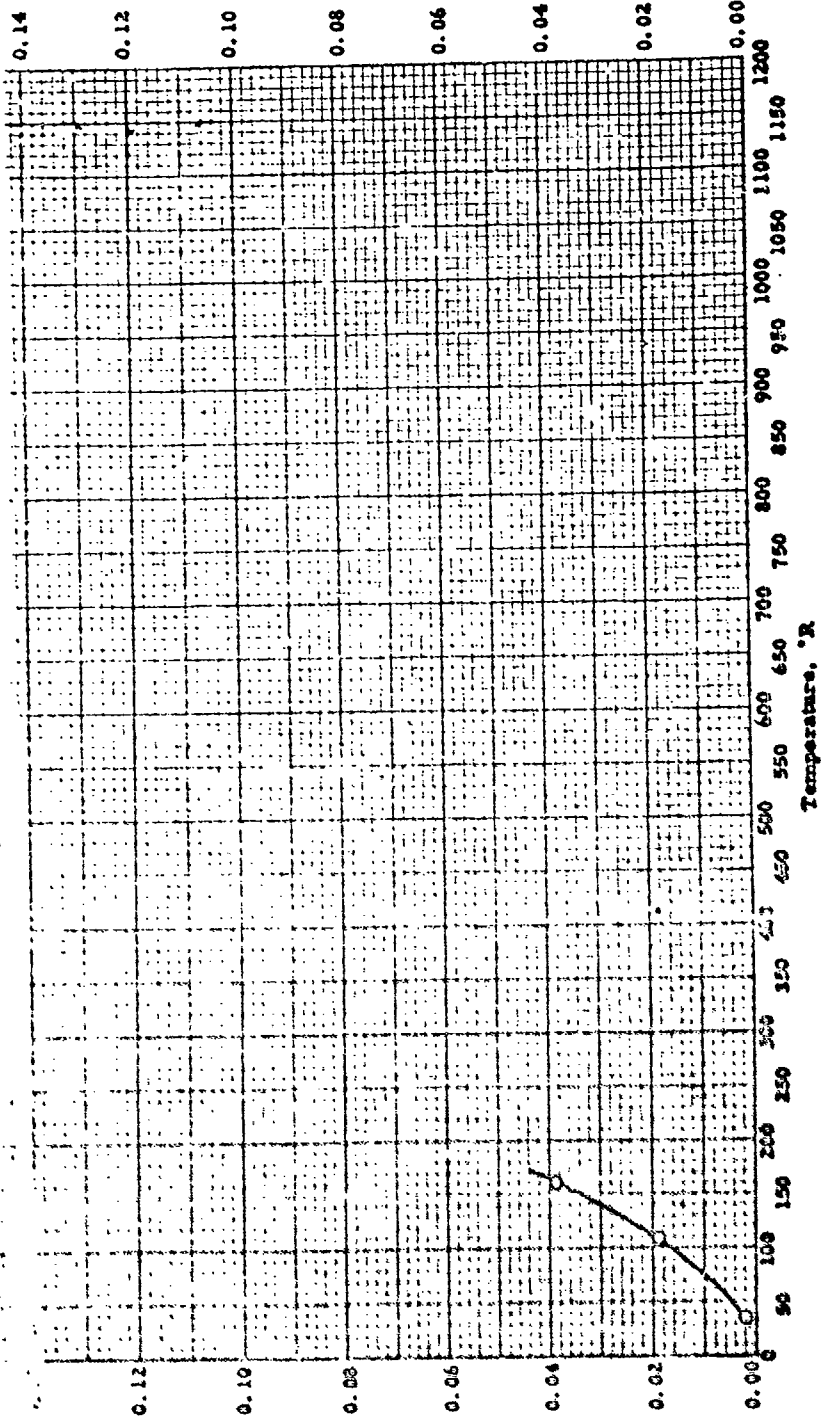
Temperature, °K

0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500 525 550 575 600 625

0.16

Specific heat, Btu/lb °R

Specific heat, cal/g °K

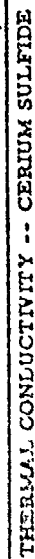


SPECIFIC HEAT -- MOLYBDENUM SULFIDE

SPECIFIC HEAT -- MOLYBDENUM SULFIDE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Smith, D. F., Brown, D. et al.	56-150	36-162	MoS ₂	Low temperature adiabatic calorimeter	Contains some free carbon and oil



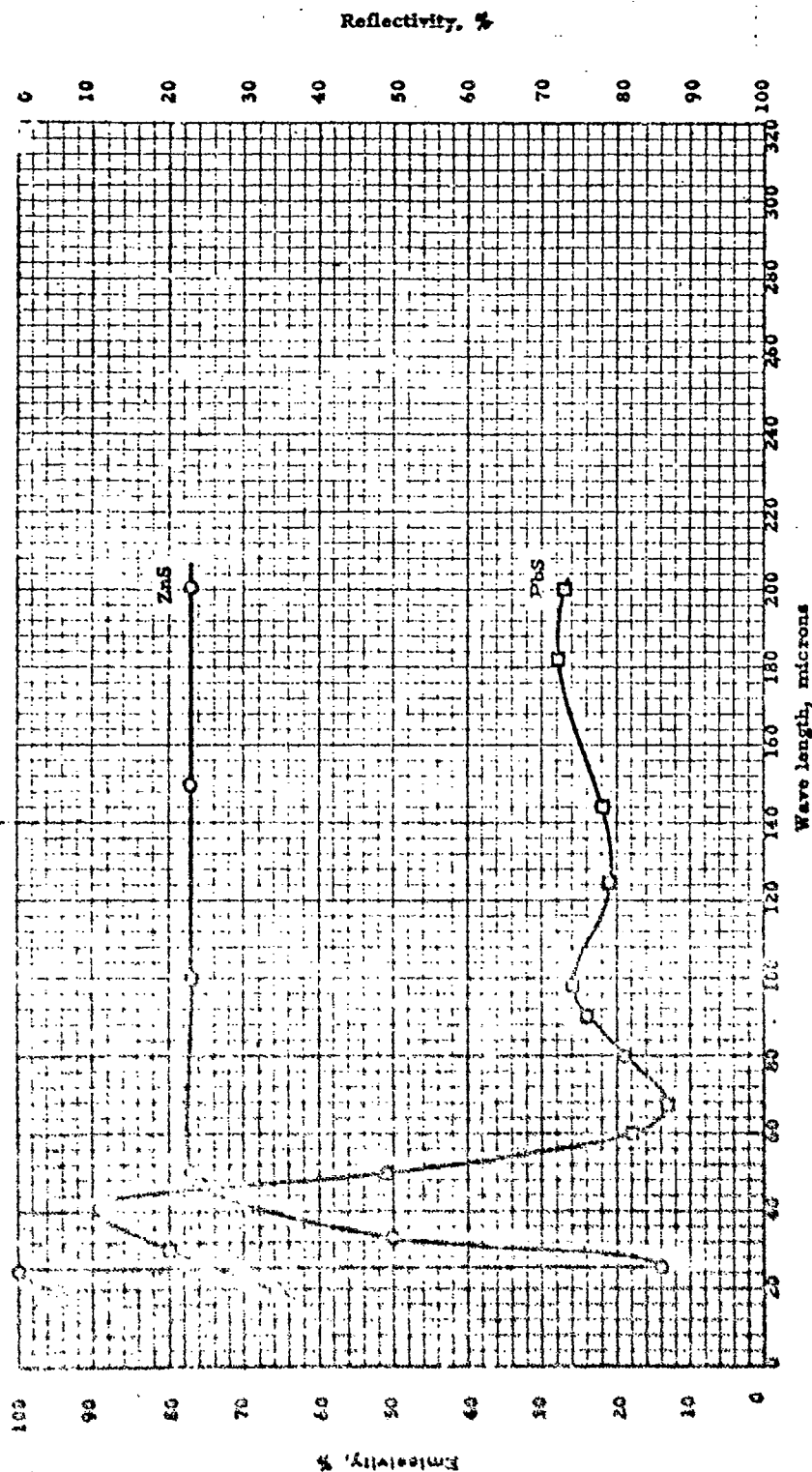
THERMAL CONDUCTIVITY -- CERIUM SULFIDE

REFERENCE INFORMATION

Investigator	Ref.	Temp., °F.	Material Composition	Test Method	Remarks
O Edwards, R. E.	52-12	Room	CeS	Comparative, disks with Bi Standard	Auth. assumes uncertainty of factor of 2

97-45 59-4:6 1227

VII - D - 6



SPECTRAL EMISSIVITY -- SULFIDES

SPECTRAL EMISSIVITY -- SULFIDES

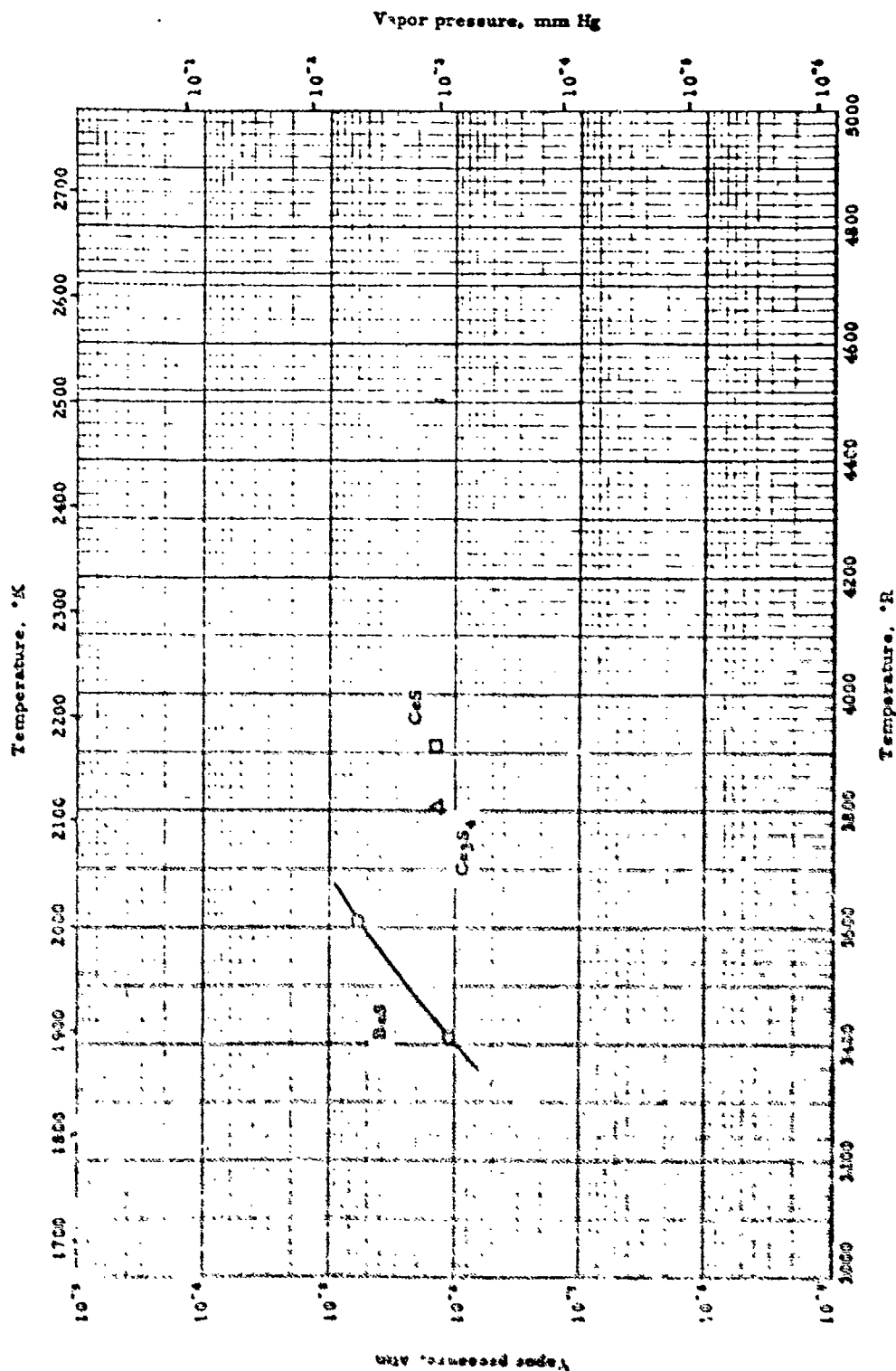
REFERENCE INFORMATION

	Investigator	Ref.	Temp., °S.	Material Composition	Test Method	Remarks
C	Yoshinaga, H.	55-98	533	ZnS	Spectral reflectivity: far infrared spectro- graph	Probably fairly pure crystals
□	End.	55-98	537	PbS	Same as above	Same as above

68-770

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VAPOR PRESSURE -- SULFIDES

60-775
WADC TR 58-475 1029

VII - D - 6

VAPOR PRESSURE -- SULFIDES

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Stewart, L., Bromley, L. et al.	48-31	3408-3606	BeS "pure", $p = 4.2 \text{ g/cm}^3$	Not described here, refers to others	Approximate measurement. Authors also report some data for ThS
O	Zastman, E. P., Brewer, L. et al.	50-27 also 48-31	3408-3912	C_{15}S crystal, $p = 5.93 \text{ g/cm}^3$	Weight loss, assuming vapors Cs and S atoms	
A	Ibid.	50-27 also 48-31	3408-3912	Ca_2S_2 , $p = 5.3 \text{ g/cm}^3$	Same as above	

PROPERTIES OF BARIUM SELENIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point.	3860° R	2140° K
Heat of Fusion.		
Heat of Vaporization. . .		
Heat of Sublimation. . .		

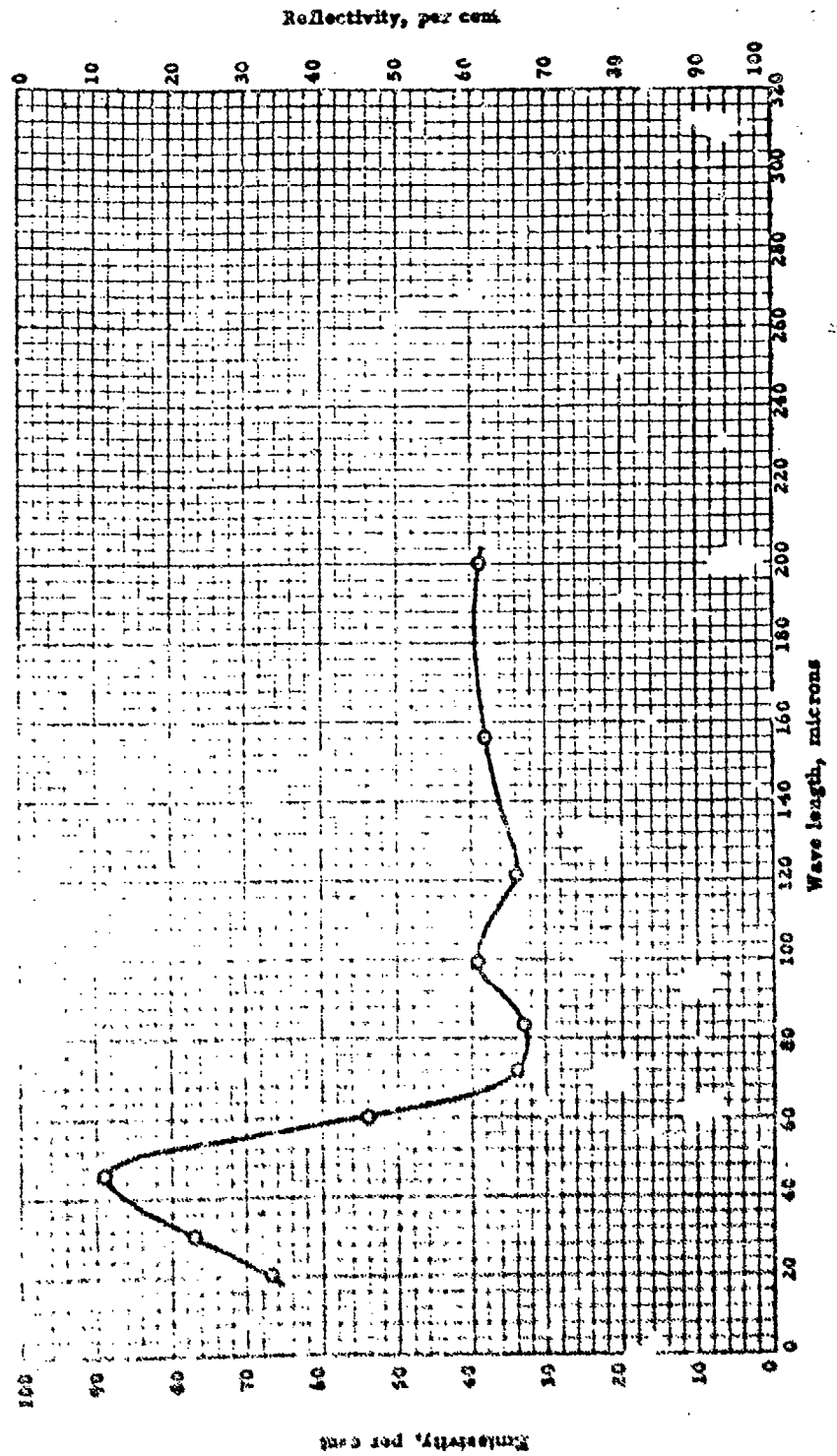
REPORTED VALUES

<u>Density:</u>	lb _m /in. ³	g/cm ³
<u>Melting Point:</u>	°R 3858 ± 36	°K 2143 ± 20
<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g

PROPERTIES OF BARIUM SELENIDE

REFERENCE INFORMATION

No.	Investigator	Ref.	Temp., °K	Material Composition	Test Method	Remarks
O	Geddes, I.E., Miller, E., and Kamarch, K.	59-13	322±359°	BaSe	MP: visual observation of order of melting of sample and standards	



SPECTRAL EMISSIVITY -- LEAD SELENIDE

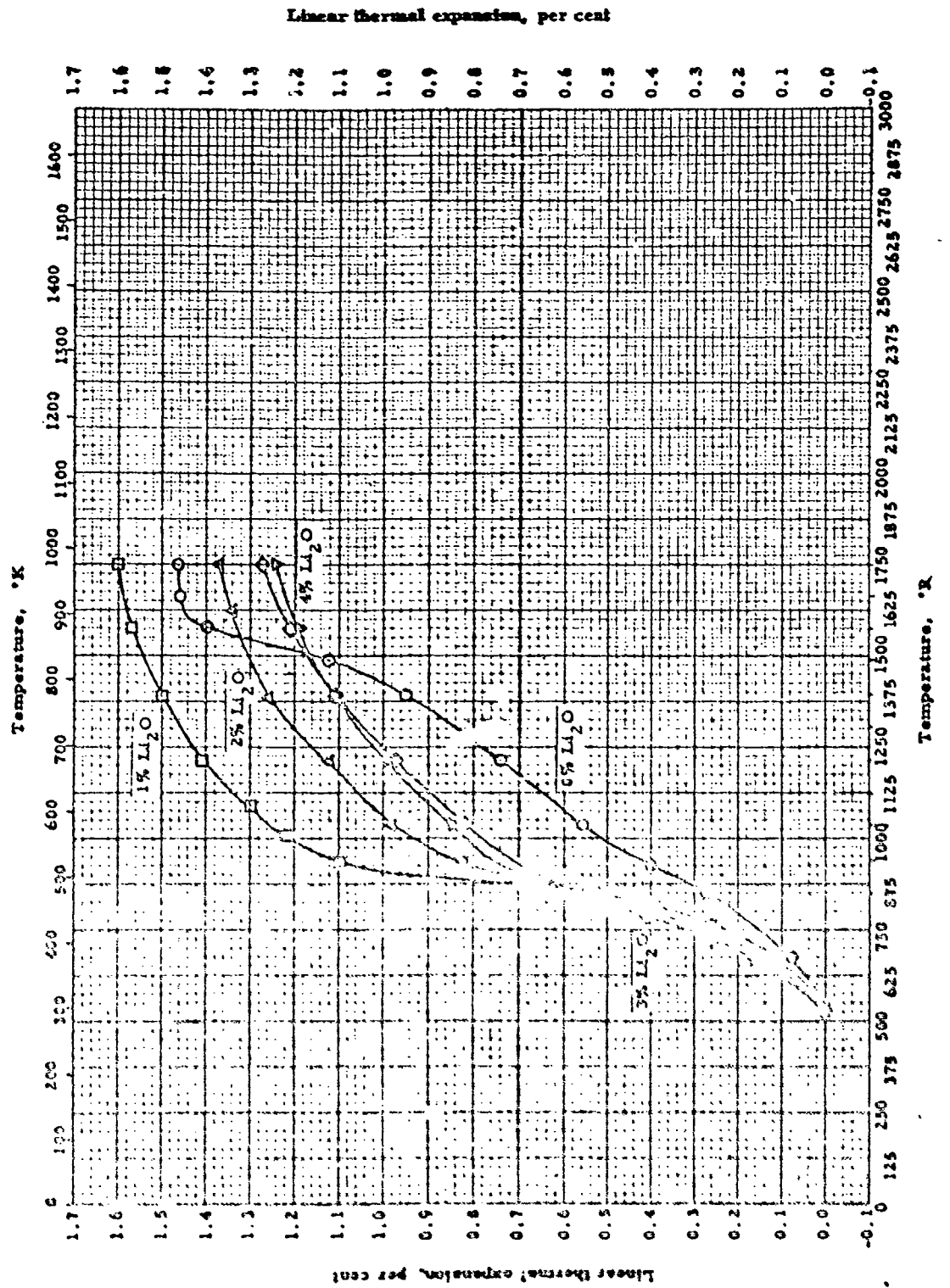
60-621
WADC TR 58-476 1031

VH - D - 6

SPECTRAL EMISSIVITY -- LEAD SELENIDE

REFERENCE INFORMATION

Ref.	Investigator	Date	Range, °R	Material Composition	Test Method	Remarks
O	Yoshinaga, H.	55-98	533	PbSe	Spectral normal reflectivity; far infrared spectrograph	Probably fairly pure crystals



37-474

4400 TR 58-476

1038

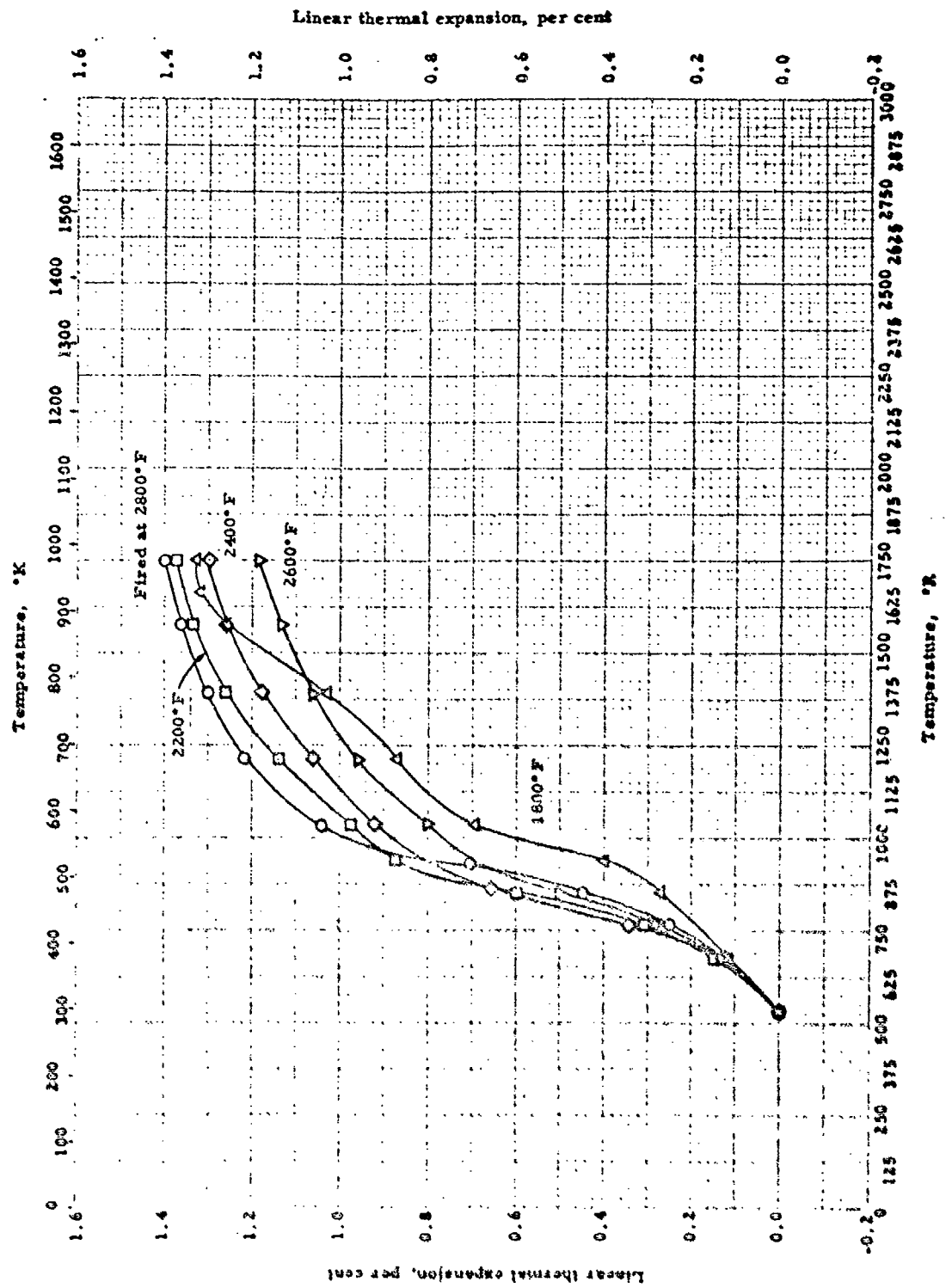
VII - 2 - 2

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY
(Effect of composition)

LINEAR THERMAL EXPANSION - LITHIUM SILICATE - QUARTZ BODY
(Effect of composition)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Snake, E. J.	54-43	528-1752	100% SiO ₂ (flint)	Fused silica tube dilatometer	Fired 5 hr. to 2200°F., soaked 1 hr., tested at 2-3°C/min. rise
□	Ibid.	54-43	528-1752	99% SiO ₂ ; 1% Li ₂ O; prepared from flint and Li ₂ CO ₃	Same as above	Same as above
△	Ibid.	54-43	528-1752	98% SiO ₂ ; 2% Li ₂ O; raw materials same as above	Same as above	Same as above
◇	Ibid.	54-43	528-1752	97% SiO ₂ ; 3% Li ₂ O; raw materials same as above	Same as above	Same as above
▽	Ibid.	54-43	528-1752	96% SiO ₂ ; 4% Li ₂ O; raw materials same as above	Same as above	Same as above

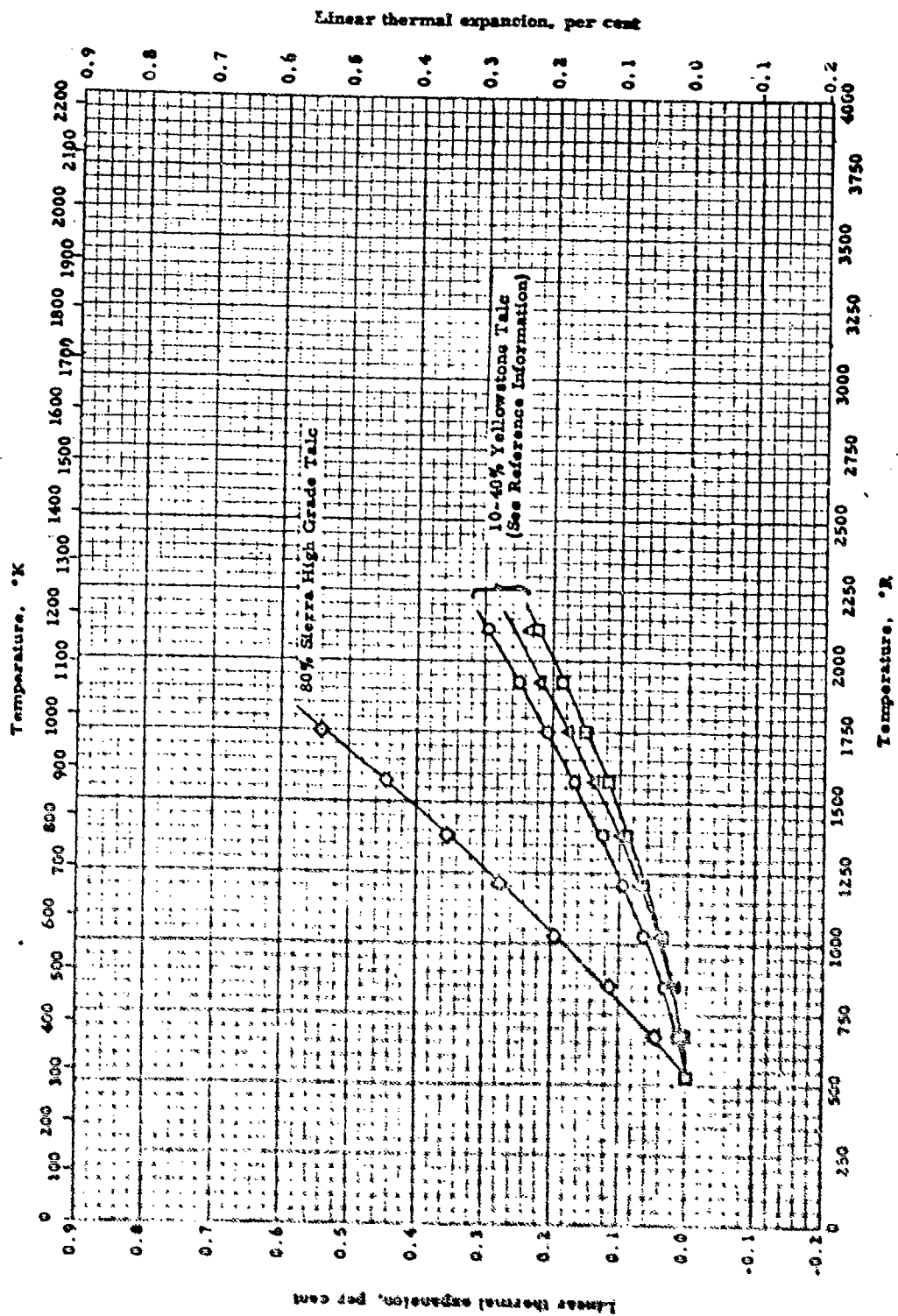


LINEAR THERMAL EXPANSION - LITHIUM SILICATE - QUARTZ BODY,
(Effect of firing temperature)

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY,
(Effect of firing temperature)

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
54-43	Smoke, E. J.	528-1752	98% SiO ₂ ; 2% Li ₂ O. Made from pot- ter's flint and Li ₂ CO ₃ . Flint compo- sition: 99.4% SiO ₂ ; 0.18% Al ₂ O ₃ ; 0.19% CaO; 0.06% ca. MgO, Fe ₂ O ₃ ; 0.03% TiO ₂ . Li ₂ CO ₃ contained 0.80% alkalis; 0.2% LiCl; 0.01% Fe ₂ O ₃	Fused silica tube dila- tometer	Fired to 2800°F in 5 hrs. and soaked for 1 hr. Heat- ing rate during test: 2-3 °C/min.
□	Ibid.	54-43 528-1752	Same as above	Same as above	Same as above except fired at 2200°F.
△	Ibid.	54-43 528-1752	Same as above	Same as above	Same as above except fired at 1800°F.
◇	Ibid.	54-43 528-1752	Same as above	Same as above	Same as above except fired at 2400°F.
▽	Ibid.	54-43 528-1752	Same as above	Same as above	Same as above except fired at 2600°F.



59-337

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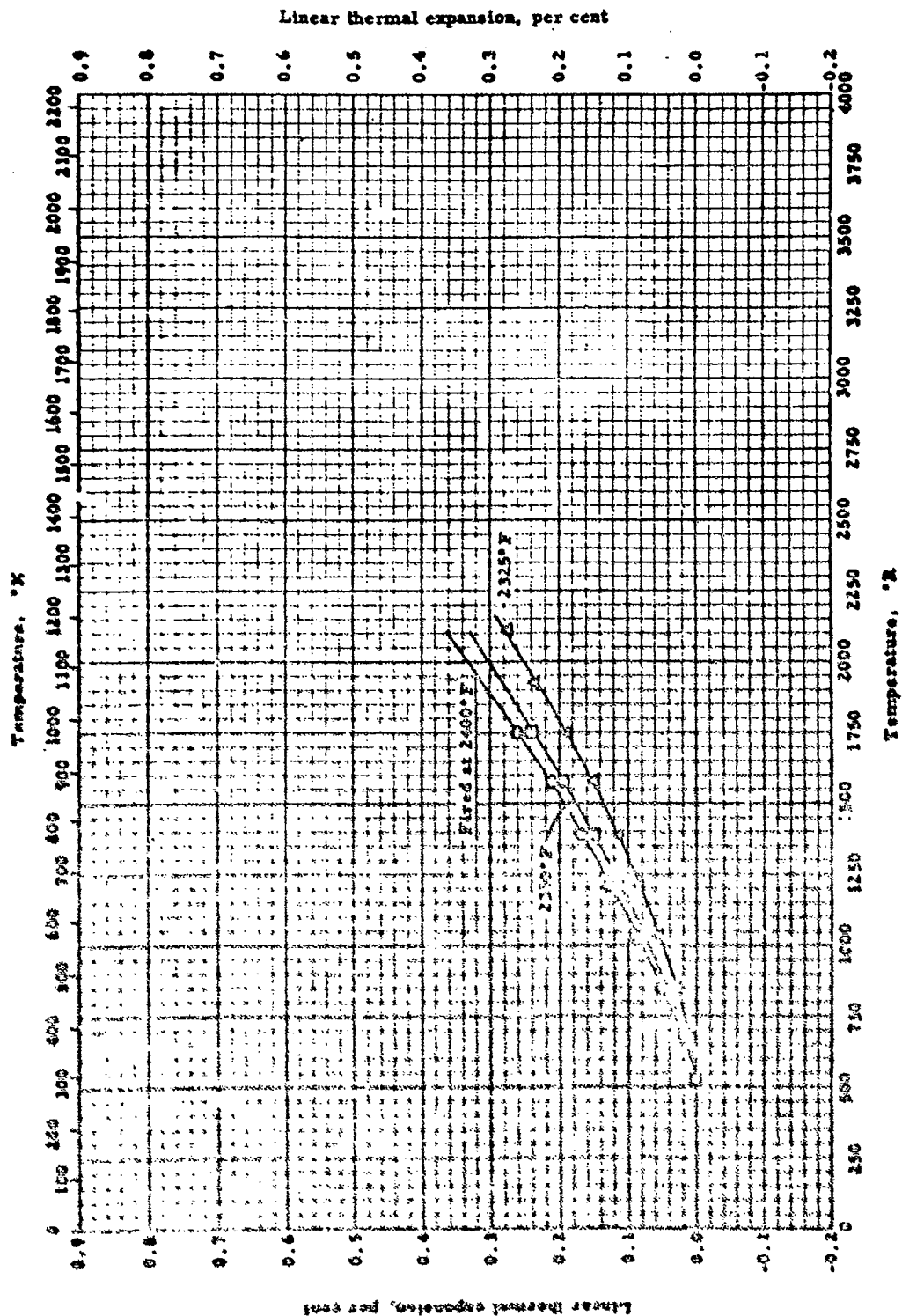
VII - E - 3 - 1

LINEAR THERMAL EXPANSION -- LOW DENSITY BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Lachar, H. E., and Warner, N. F.	54-47	672-2112	40% Yellowstone talc; 37.3% E. P. K.; 13.6% Al_2O_3 ; 9.1% $BaCO_3$	Quartz tube dilatometer	Fired at 1275°C; absorption 6.3%
○	Ibid.	54-49	672-2112	61.7% E. P. K.; 15.8% $MgCO_3$; 13.4% Yellowstone talc; 9.1% $BaCO_3$	Same as above	Fired at 1288°C; absorption 7.8%
△	Ibid.	54-49	672-2112	56.6% E. P. K.; 14.3% $MgCO_3$; 12.3% Yellowstone talc; 8.3% ca. $BaCO_3$, 9% SiO_2	Same as above	Fired at 1260°C; absorption 18.8%
○	New Jersey Ceramic Research Station	55-22	672-1752	40% Sierra high grade talc; 10% ca. $BaCO_3$, E. P. K. clay	Fused silica tube dilatometer	Tested at 2-3°C/min. rise



54-778

WADC TR 53-476

1041

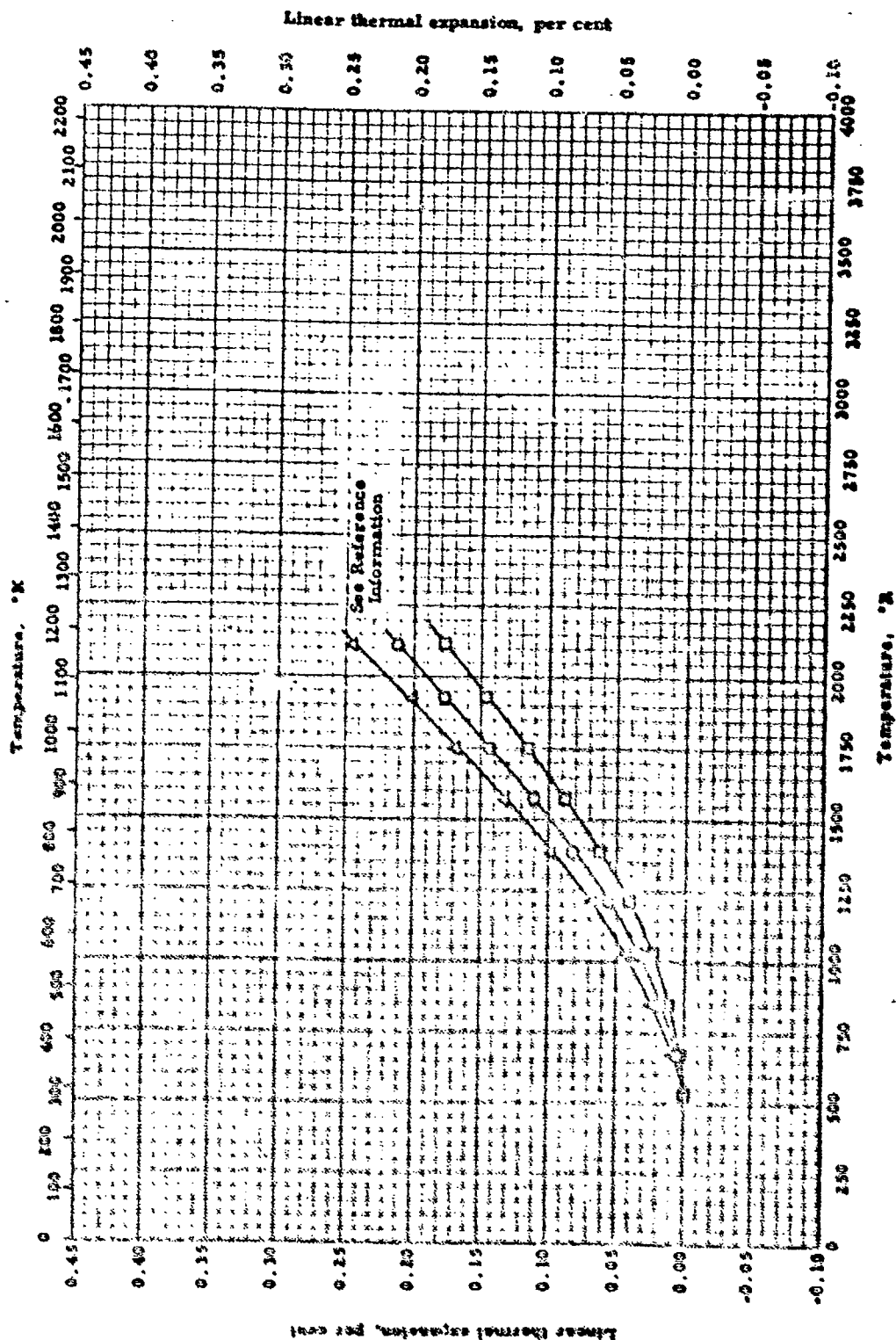
VII - E - 1

LINEAR THERMAL EXPANSION -- MEDIUM DENSITY BARIUM CORDIERITE

LEVEAP THERMAL EXPANSION -- MEDIUM DENSITY BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	23-45	528-1752	32% E.P.K.; 32% Sparks North Carolina; 17% BaCO ₃ ; 11% potter's flint; 6% Sierra high grade talc	Silica tube dilatometer	Fired at 2400°F; (3BaO · 2MgO · 8Al ₂ O ₃ · 26SiO ₂)
□	IdA.	53-45	528-1752	Same as above	Same as above	Fired at 2350°F; (3BaO · 2MgO · 8Al ₂ O ₃ · 26SiO ₂)
Δ	Lamar, M. A. and Warner, M. F.	54-49	672-2112	45.4% E.P.K.; 45.4% Sierrallite; 9.1% BaCO ₃	Quartz tube dilatometer	Fired at 2327°F; absorp- tion 3.2%



59-492

WADC TR 59-476

1043

VII - E - 1 - 1

LINEAR THERMAL EXPANSION -- DENSE BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- DENSE BARIUM CORDIERITE

REFERENCE INFORMATION

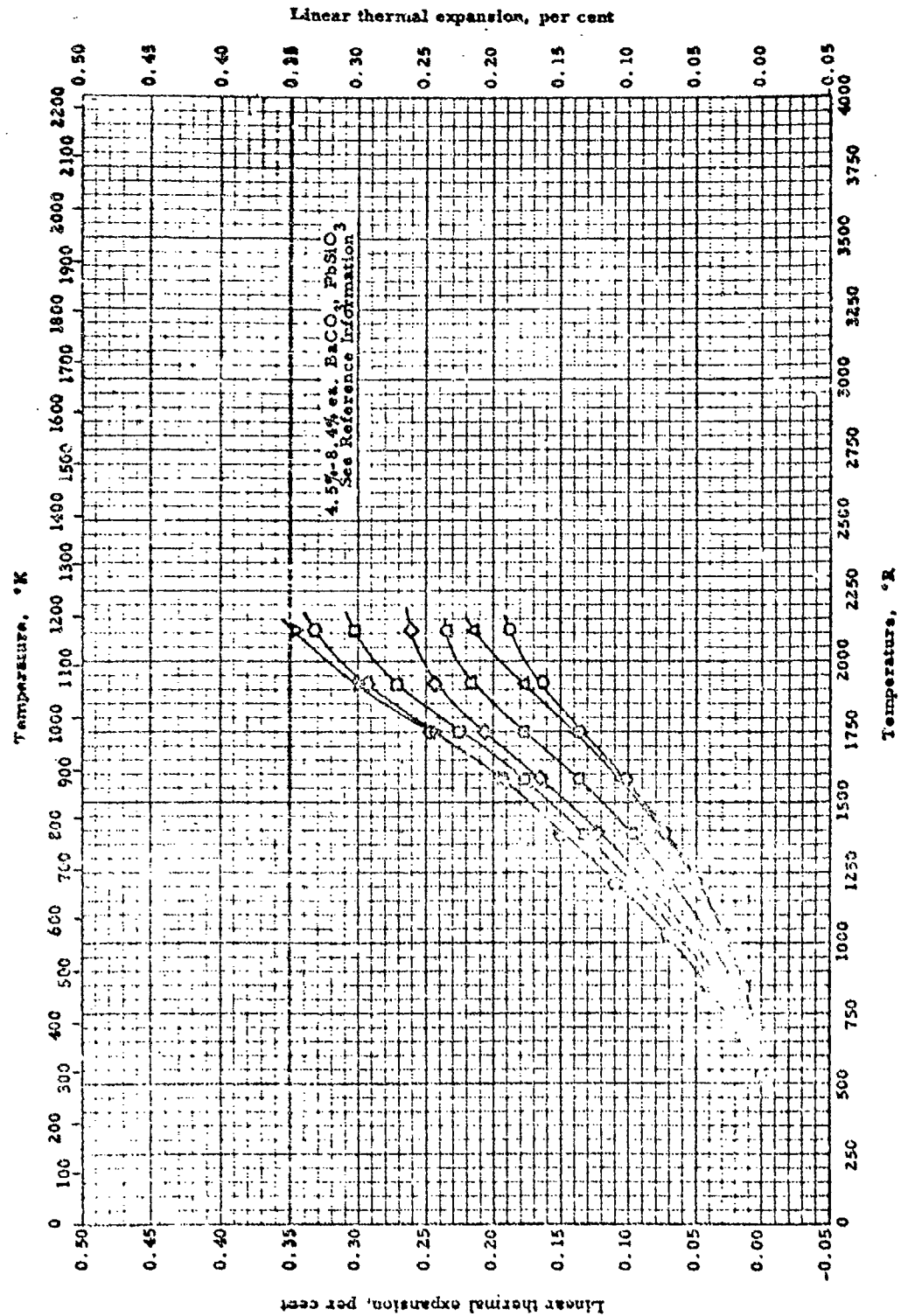
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lamar, E. S. and Warner, N. F.	54-49	672-2112	68.2% E.P.K.; 22.7% Yellowstone talc; 9.1% BaCO ₃	Quartz tube dilatometer	Fired at 1288°C; absorption 0.3%
□	Ibid.	54-49	672-2112	55.9% E.P.K.; 20.0% Yellowstone talc; 9.1% BaCO ₃ ; 5% MgCO ₃	Same as above	Fired at 1300°C; absorption 0.5%
Δ	Ibid.	54-49	672-2112	45.4% E.P.K.; 37.1% Sierrallite; 9.1% BaCO ₃ ; 8.4% Yellowstone talc	Same as above	Fired at 1288°C; absorption 0.7%

59-638

WADC TR 58-476

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VII - E - 3 - k

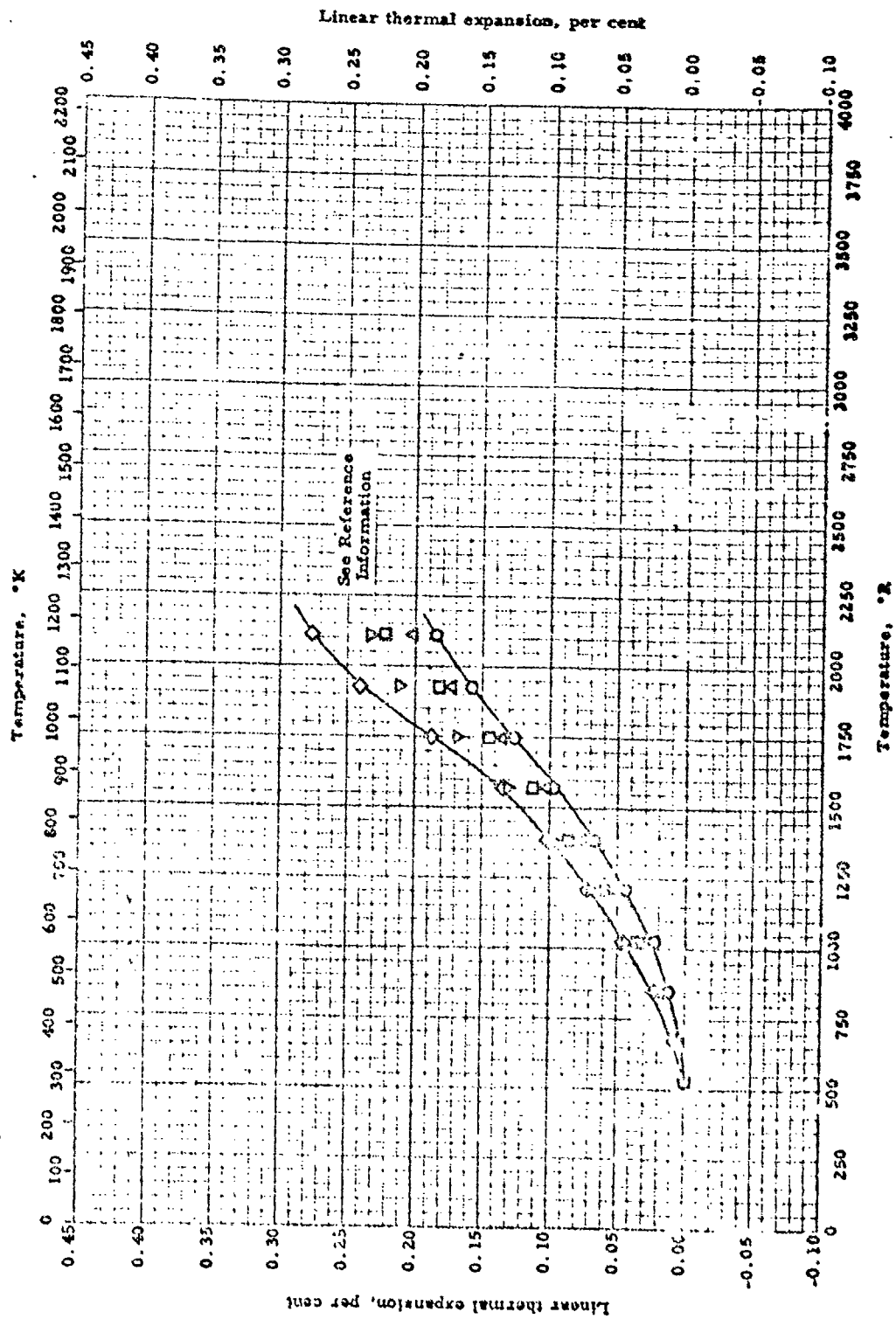


LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD-BARIUM CORDERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD-BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Linnar, H. S. and Warner, N. F.	54-49	672-2112	60.4% E.P.K.; 18.3% Yellowstone talc; 8.4% ea. BaCO ₃ , PbSiO ₃ ; 4.6% MgCO ₃	Quartz tube dilatometer	Fired at 1275°C; absorption 7.3%
□	Ibid.	54-49	672-2112	41.3% E.P.K.; 41.7% Sierrallite; 9.3% ea. BaCO ₃ , PbSiO ₃	Same as above	Fired at 1232°C; absorption 10.8%
△	Ibid.	54-49	672-2112	61.7% E.P.K.; 12.2% MgCO ₃ ; 13.4% Yellowstone talc; 4.5% ea. BaCO ₃ , PbSiO ₃	Same as above	Fired at 1316°C; absorption 10.9%
◇	Ibid.	54-49	672-2112	41.7% E.P.K.; 3% Sierrallite; 8.3% ea. BaCO ₃ , PbSiO ₃ ; 7.7% Yellowstone talc	Same as above	Fired at 1219°C; absorption 6.7%
▽	Ibid.	54-49	672-2112	46% Yellowstone talc; 37.3% E.P.K.; 13.6% Al ₂ O ₃ ; 4.5% ea. BaCO ₃ , PbSiO ₃	Same as above	Fired at 1260°C; absorption 9.6%
○	Ibid.	54-49	672-2112	56.7% Yellowstone talc; 34.2% E.P.K.; 12.5% Al ₂ O ₃ ; 8.3% ea. BaCO ₃ , PbSiO ₃	Same as above	Fired at 1246°C; absorption 11.5%
□	Ibid.	54-49	672-2112	56.6% E.P.K.; 14.5% MgCO ₃ ; 12.3% Yellowstone talc; 8.3% ea. BaCO ₃ , PbSiO ₃	Same as above	Fired at 1260°C; absorption 13.9%



59-782

WADC TR 58-476

1047

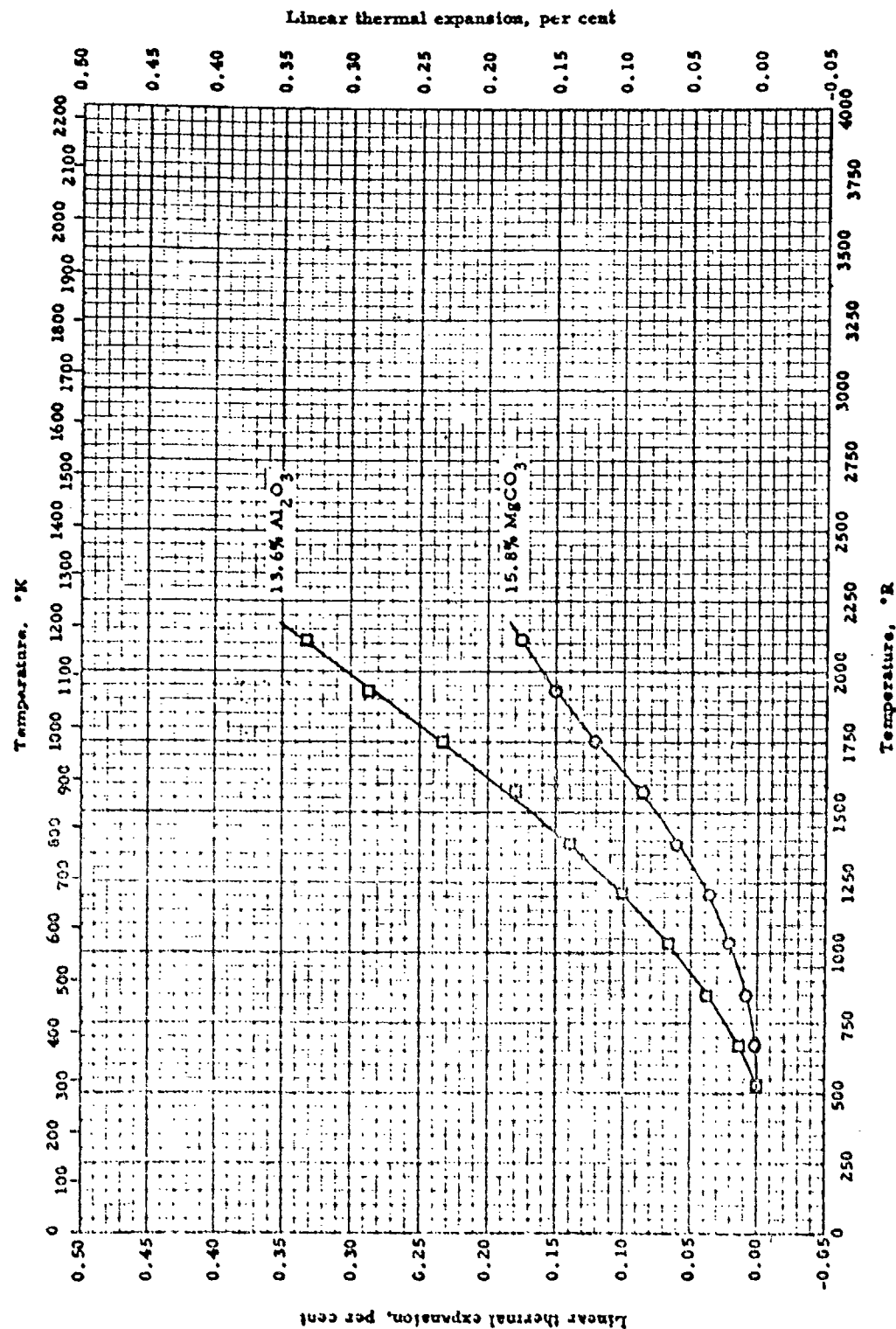
VII - E - 3 - k

LINEAR THERMAL EXPANSION -- HIGH DENSITY LEAD-BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- HIGH DENSITY LEAD-BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Ammer, H. S. and Warner, N. F.	54-49	672-2112	62.5% E. P. K.; 20.8% Yellowstone talc; 8.3% ea. BaCO_3 , PbSiO_3	Quartz tube dilatometer	Fired at 1260°C; absorption 0.3%
□	Ibid.	54-49	672-2112	63.2% E. P. K.; 22.7% Yellowstone talc; 4.5% ea. BaCO_3 , PbSiO_3	Same as above	Fired at 1260°C; absorption 0.6%
△	Ibid.	54-49	672-2112	65.9% E. P. K.; 20.0% Yellowstone talc; 5% MgCO_3 ; 4.5% ea. BaCO_3 , PbSiO_3	Same as above	Fired at 1275°C; absorption 0.7%
◇	Ibid.	54-49	672-2112	45.5% ea. E. P. K., Sierralite; 4.5% ea. BaCO_3 , PbSiO_3	Same as above	Fired at 1246°C; absorption 0.7%
▽	Ibid.	54-49	672-2112	45.6% E. P. K.; 37.1% Sierralite; 8.4% Yellowstone talc; 4.5% ea. BaCO_3 , PbSiO_3	Same as above	Fired at 1204°C; absorption 0.8%



LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD CORDIERITE

59-346

WADC TR 58-476

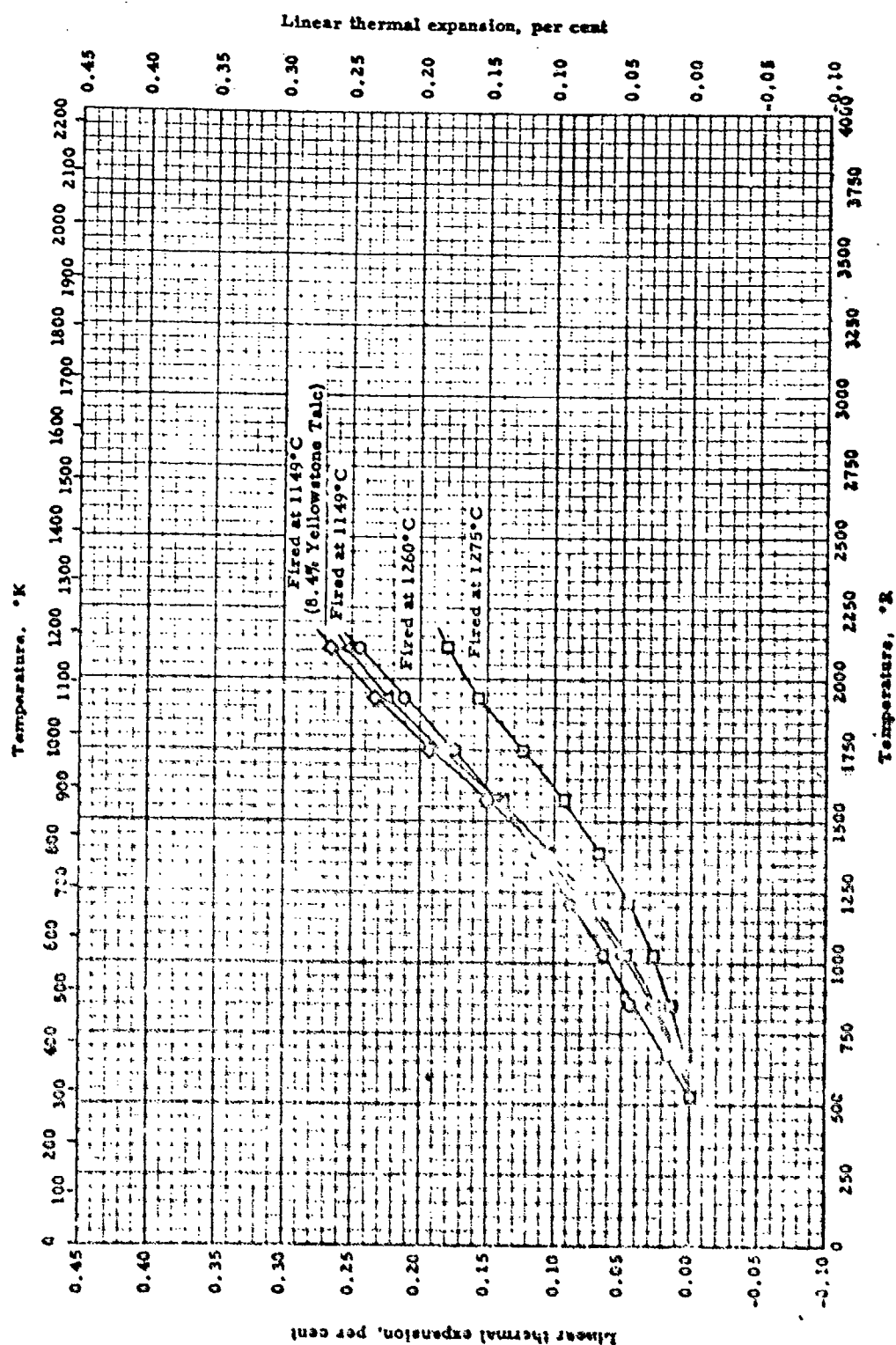
1049

VII - E - 3 - k

LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	61.7% E.P.K.; 15.8% MgCO ₃ ; 13.4% Yellowstone talc; 9.1% PbSiO ₃	Quartz tube dilatometer	Fired at 1316°C; absorption 8.9%
□	Ibid.	54-49	672-2112	40% Yellowstone talc; 37.3% E.P.K.; 13.6% Al ₂ O ₃ ; 9.1% PbSiO ₃	Same as above	Fired at 1260°C; absorption 8.6%



LINEAR THERMAL EXPANSION -- DENSE LEAD CORDIERITE

59-834

WADC TR 55-476

1051

VII - E - 3 - R

LINEAR THERMAL EXPANSION -- DENSE LEAD CORDIERITE

REFERENCE INFORMATION

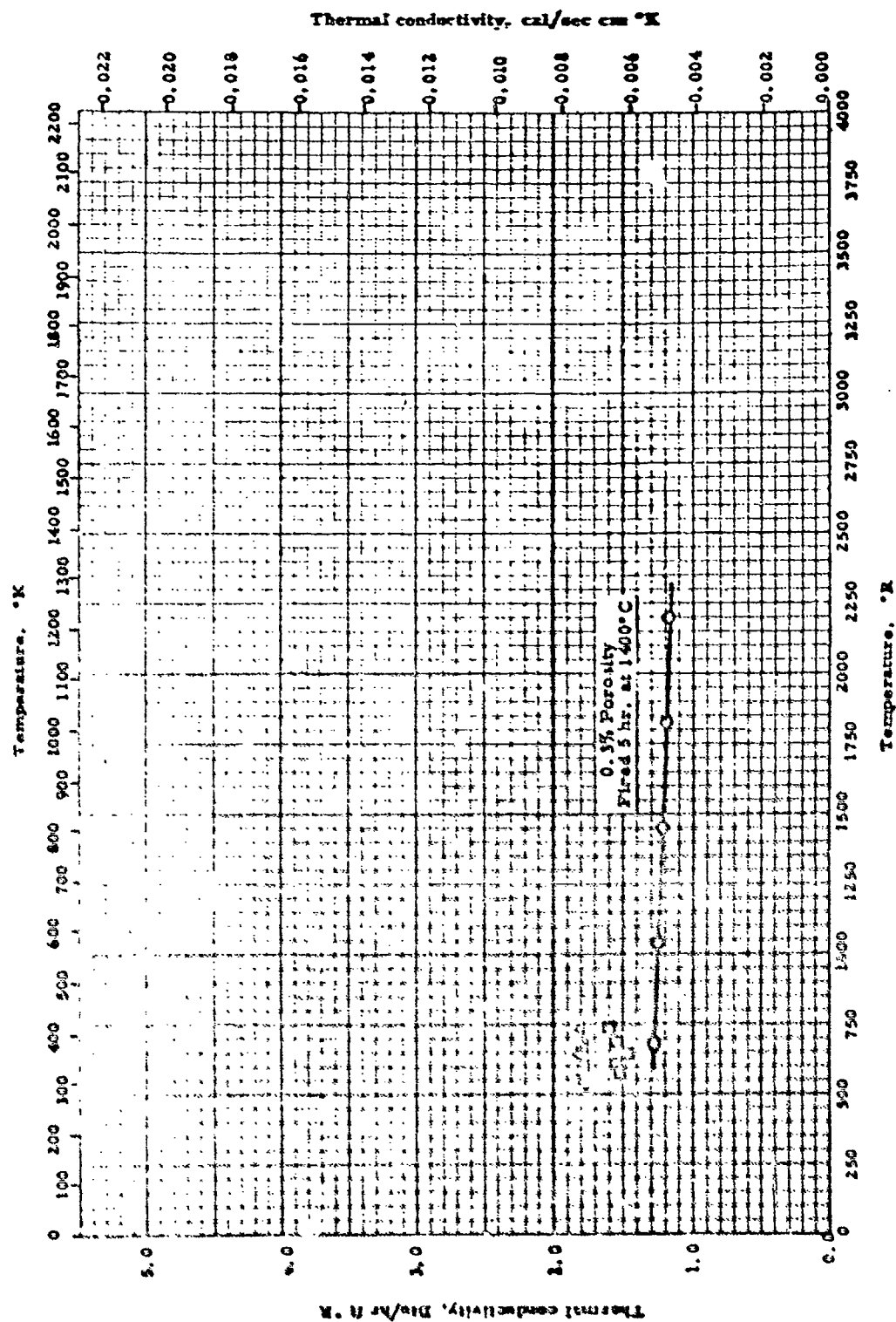
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	62.2% E.P.K.; 22.7% Yellowstone Talc; 9.1% PbSiO ₃	Quartz tube dilatometer	Fired at 1260°C; 0.6% absorption.
□	Ibid.	54-49	672-2112	66.2% E.P.K.; 20.6% Yellowstone Talc; 9.2% PbSiO ₃ ; 4.6% MgCO ₃	Same as above	Fired at 1275°C; 0.8% absorption.
△	Ibid.	54-49	672-2112	45.4% E.P.K.; 45.4% Sierrallite; 9.1% PbSiO ₃	Same as above	Fired at 1149°C; 0.1% absorption.
◇	Ibid.	54-49	672-2112	45.4% E.P.K.; 37.1% Sierrallite; 9.1% PbSiO ₃ ; 8.4% Yellowstone Talc	Same as above	Fired at 1149°C; 0.1% absorption.

59-466

WADC TR 58-476

1053

W - 3 - 11A



Thermal conductivity -- CORDIERITE

Thermal Conductivity -- CORDIERITE

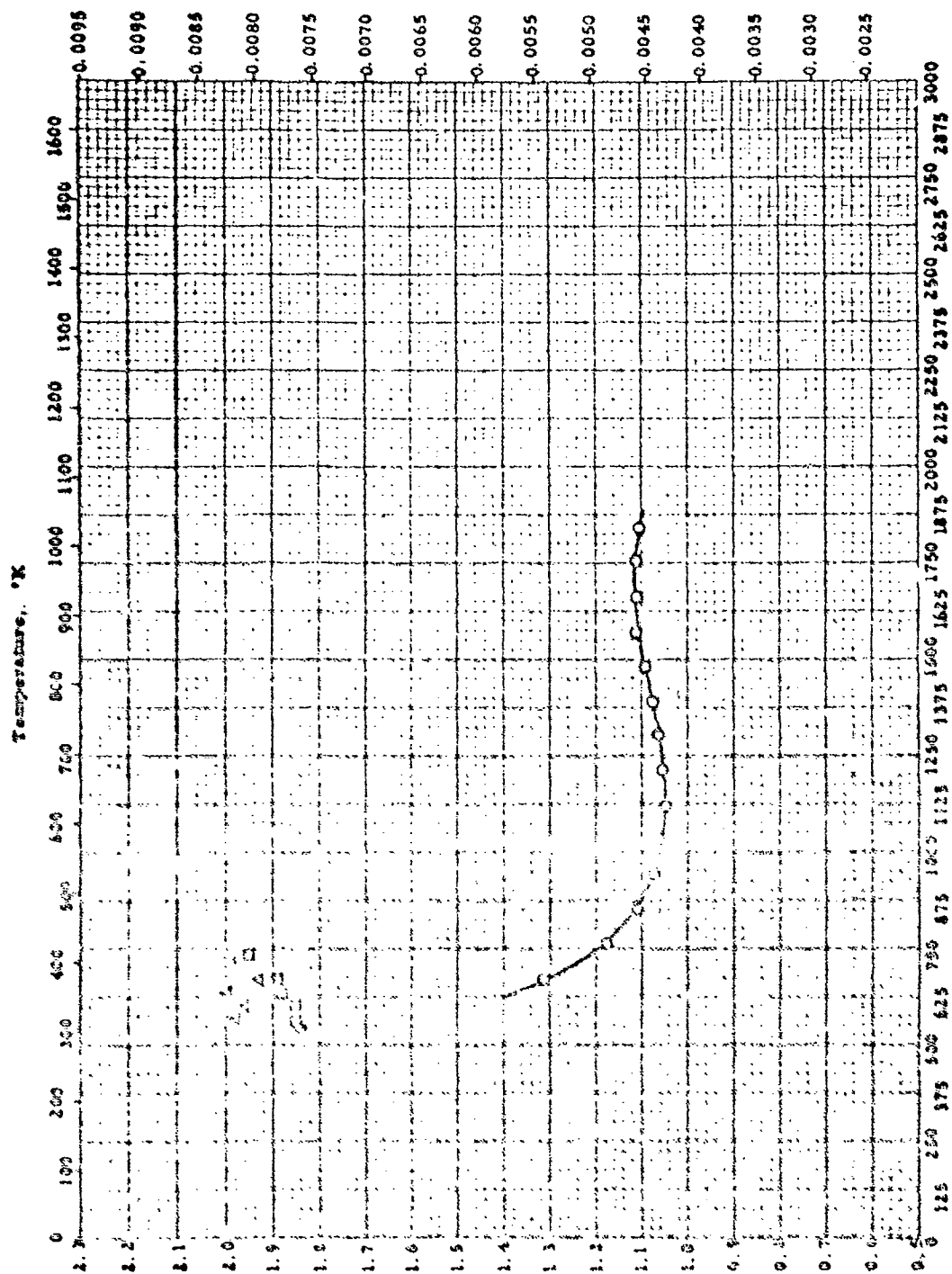
REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Stetson, W. R. and Eubank, E. A.	55-59	672-2262	52.15% Florida kaolin (EPK); 34.6% C and C ball clay; 7.15% MgO; 7.25% Fe; 2.22% MnO ₂ ; 6% Sierra talc. p = 132 lb./ft. ³ ; porosity = 0.3%	Radial heat flow in cylinder	Fired 6 hr. at 1400°C
New Jersey Ceramic Research Station	54-59	576-735	35.95% eucalcine 33D; 25.57% ea. Edgar Plastic kaolin and N. Carolina kaolin, 10% Old Mine No. 4 ball clay	Comparative; rods	Tested in vacuum
U.S.	54-59	576-735	59.15% Edgar Plastic kaolin; 35.95% eucalcine 33D; 10.90% Old Mine No. 4 ball clay	Same as above	Same as above
Oak Ridge National Lab.	51-55C	546	Cordierite 202	Not described here; refers to others	Measured by O. Sieman, C. D. Bopp and R. L. Towns

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Thermal conductivity, $\text{Btu/hr ft}^2 \text{ } ^\circ\text{R}$ Thermal conductivity, $\text{cal/sec cm } ^\circ\text{K}$

Temperature, °R

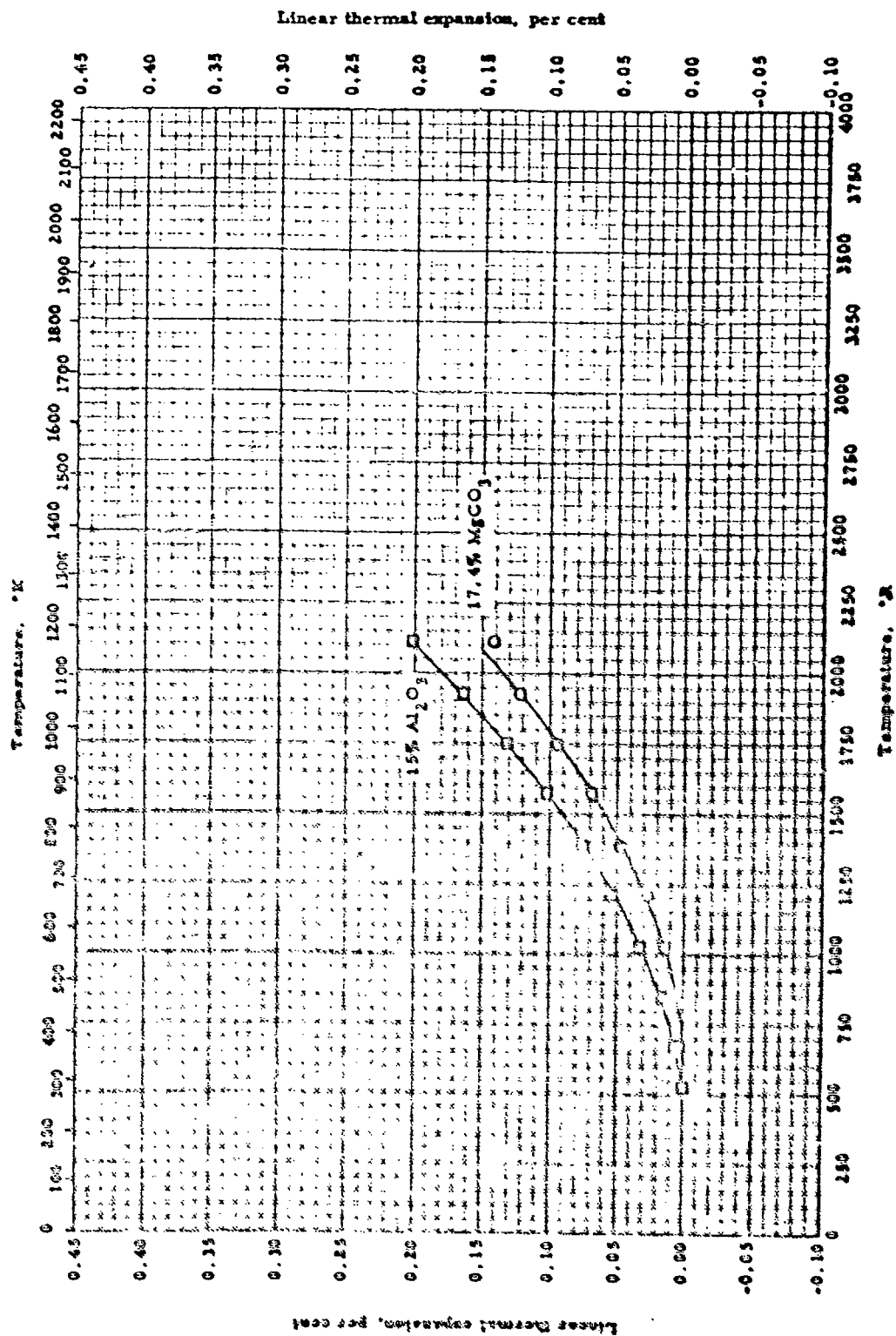
THERMAL CONDUCTIVITY -- FIRED STEATITE

VII - E - 3

TERMOAL CONDUCTIVITY -- FIRED STEATITE

REFERENCE INFORMATION

Author	Date	Source	Material Composition	Test Method	Remarks
W. R. and E. A.	12-10	472-1642	Steatite: 20% Murchison talc; 10% Tamm. ball clay; 25% SiO ₂ vs talc; 15% binder Porosity: 0.25; ρ : 2.56 g/cm ³	Stacked disc method	Axial heat flow minimised during tests. Fired 1 hr. at 1305°C on pottery flint
W. R. and E. A.	14-69	514-735	Commercial Steatite #12C-2	Comparative, rods, in vacu- um. Redetermined with vacuum method	
	14-69	510-927	Steatite #1CB-2	Same as above	
W. R. and E. A.	17-15	545	Steatite	Not described here, refers to others	



LINEAR THERMAL EXPANSION -- LOW DENSITY CONDIERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY CORDIERITE

REFERENCE INFORMATION

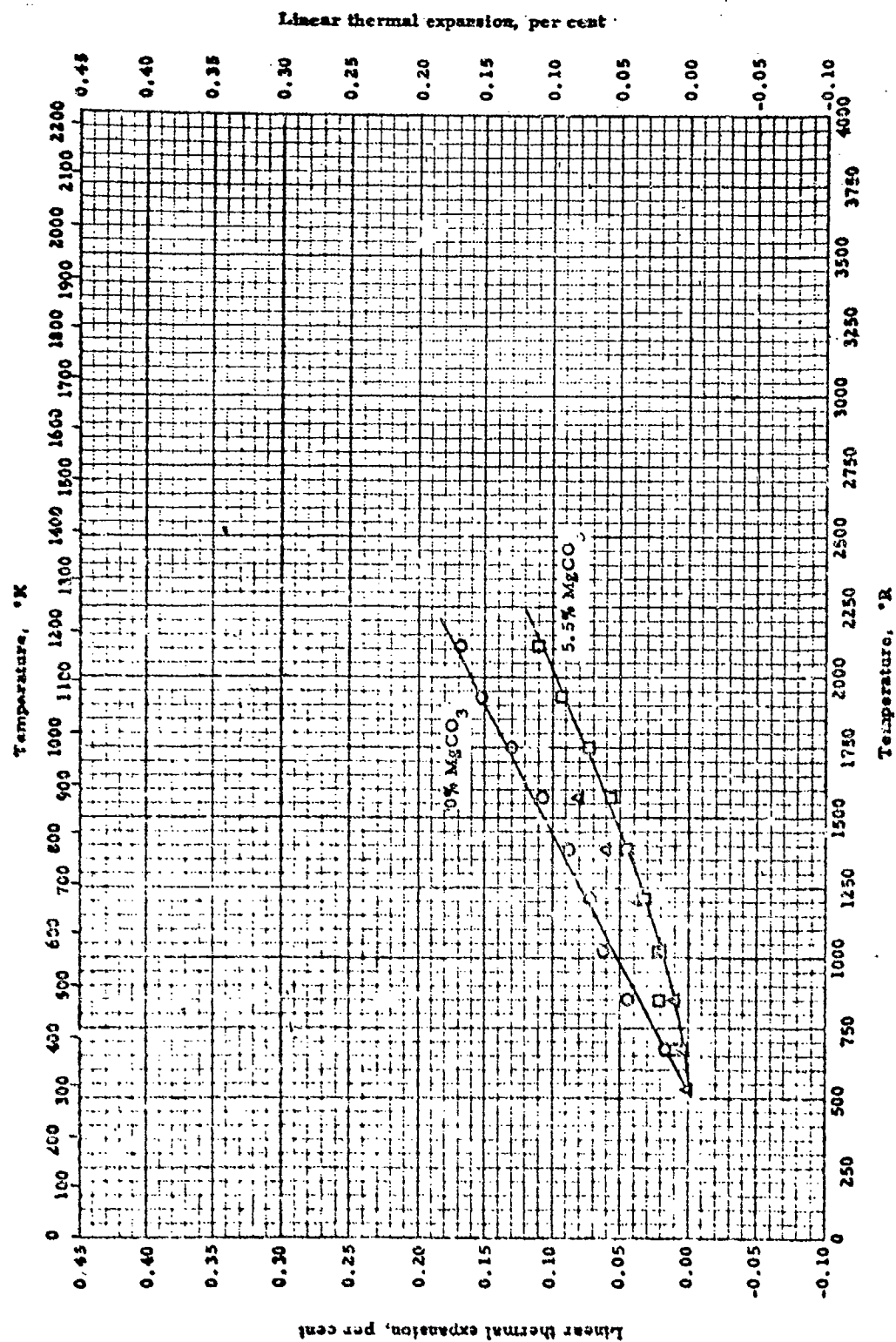
Ref.	Investigator	Range, °F.	Material Composition	Test Method	Remarks
54-49	Lamar, R. G. and Warner, N. F.	672-2112	67.9% E.P.K.; 17.4% MgCO ₃ ; 14.7% Yellowstone talc	Quartz tube dilatometer	Fired at 1316°C; absorp- tion 13.5%
54-49	Ibid.	672-2112	64% Yellowstone talc; 41% E.P.K.; 15% Al ₂ O ₃	Same as above	Fired at 1300°C; absorp- tion 9.8%

59-347

WADC TR 58-476

1059

VII - E - 3

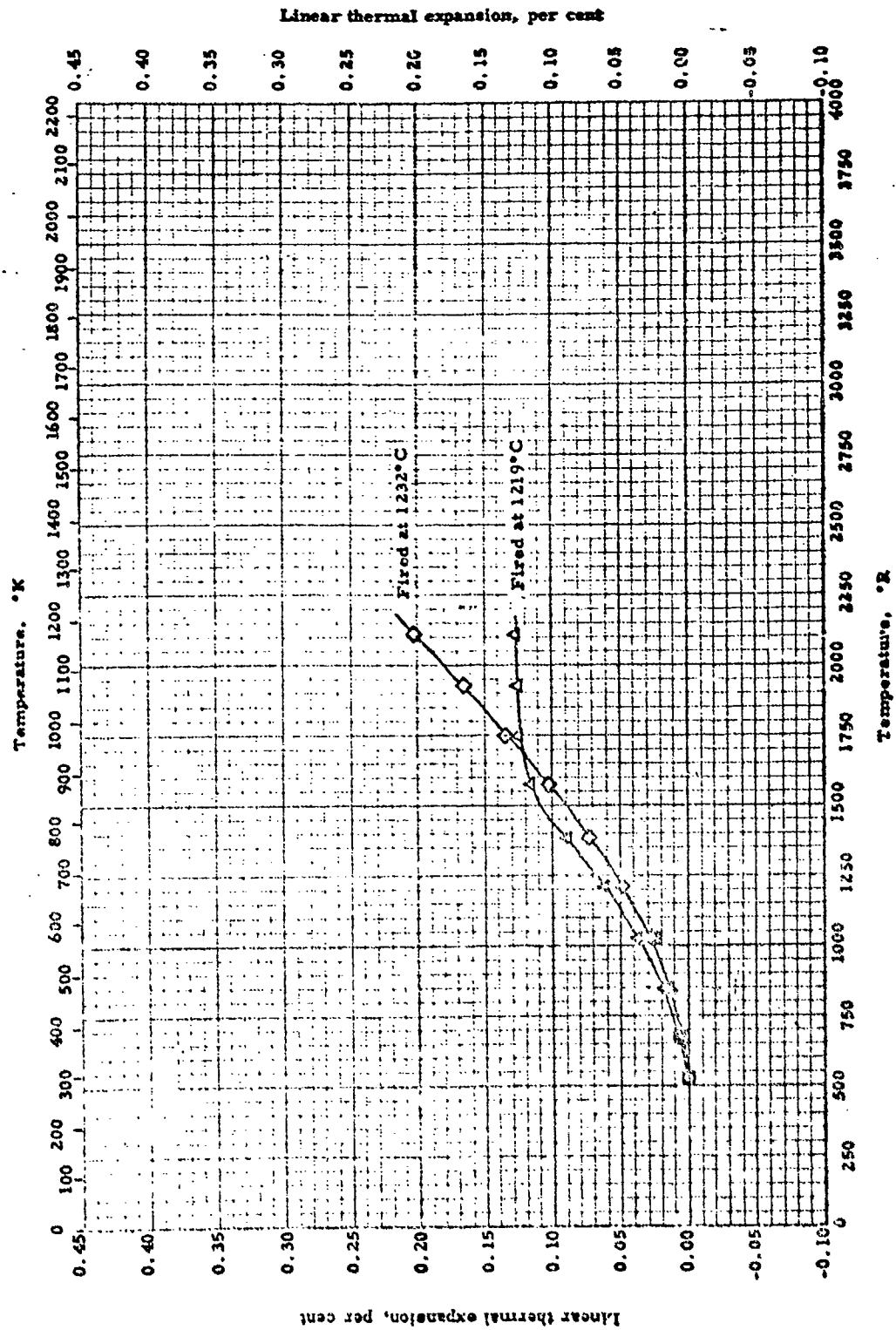


LINEAR THERMAL EXPANSION -- MEDIUM DENSITY CORDIERITE

LINEAR THERMAL EXPANSION -- MEDIUM DENSITY CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	75% E. P. K.; 25% Yellowstone talc	Quartz tube dilatometer	Fired at 1316°C; absorption 1.5%
□	Ibid.	54-49	672-2112	72.3% E. P. K.; 21.9% Yellowstone talc; 5.5% $MgCO_3$	Same as above	Fired at 1343°C; absorption 2.2%
△	Durbin, E. A. and Hartman, C. G.	52-31	528-1572	Not given	Interferometer	Fired 16 hr. at 1350°C

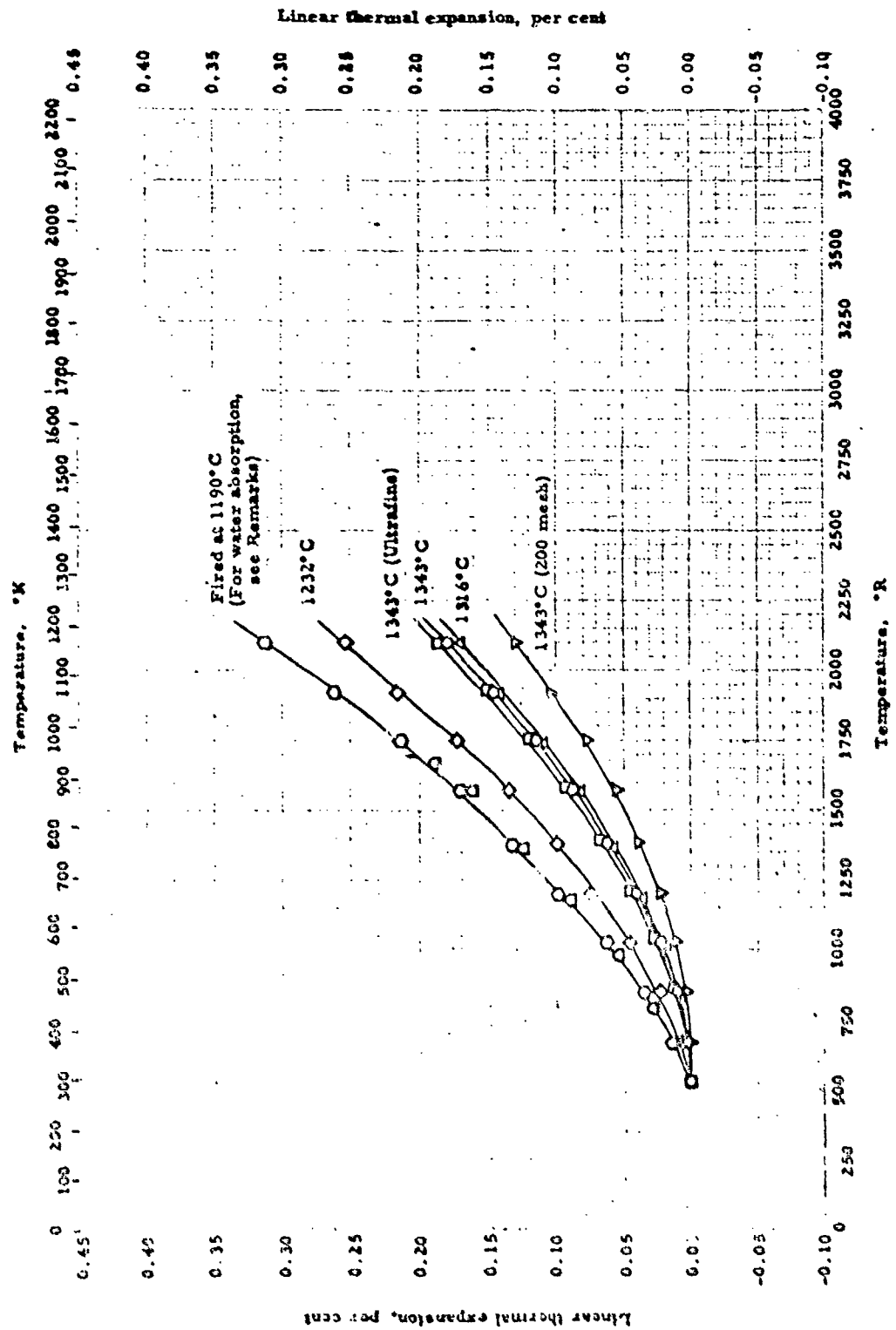


LINEAR THERMAL EXPANSION -- DENSE CORDIERITE

LINEAR THERMAL EXPANSION -- DENSE CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gehler, K. A. and Wisely, H. R.	49-19	528-1032	69% Ball clay; 17.55% MgCO ₃ ; 7.1% talc; 6.35% Al(OH) ₃ ; apparent $\rho = 145 \text{ lb}_m/\text{ft}^3$; true $\rho = 162 \text{ lb}_m/\text{ft}^3$	Not given	
□	Ibid.	49-19	528-1032	48.1% Zircon; 32% Ball clay; 14.2% MgCO ₃ ; 5.7% talc; apparent $\rho = 140 \text{ lb}_m/\text{ft}^3$; true $\rho = 155 \text{ lb}_m/\text{ft}^3$	Same as above	
△	Larnet, H. S. and Warner, H. F.	54-49	672-2112	50% E.F.K.; 40.8% Sieralite; 9.2% Yellowstone talc	Quartz tube dilatometer	Fired at 1219°C; absorption 0.6%
◇	Ibid.	54-49	672-2112	Same as above	Same as above	Fired at 1232°C; absorption 0.5%

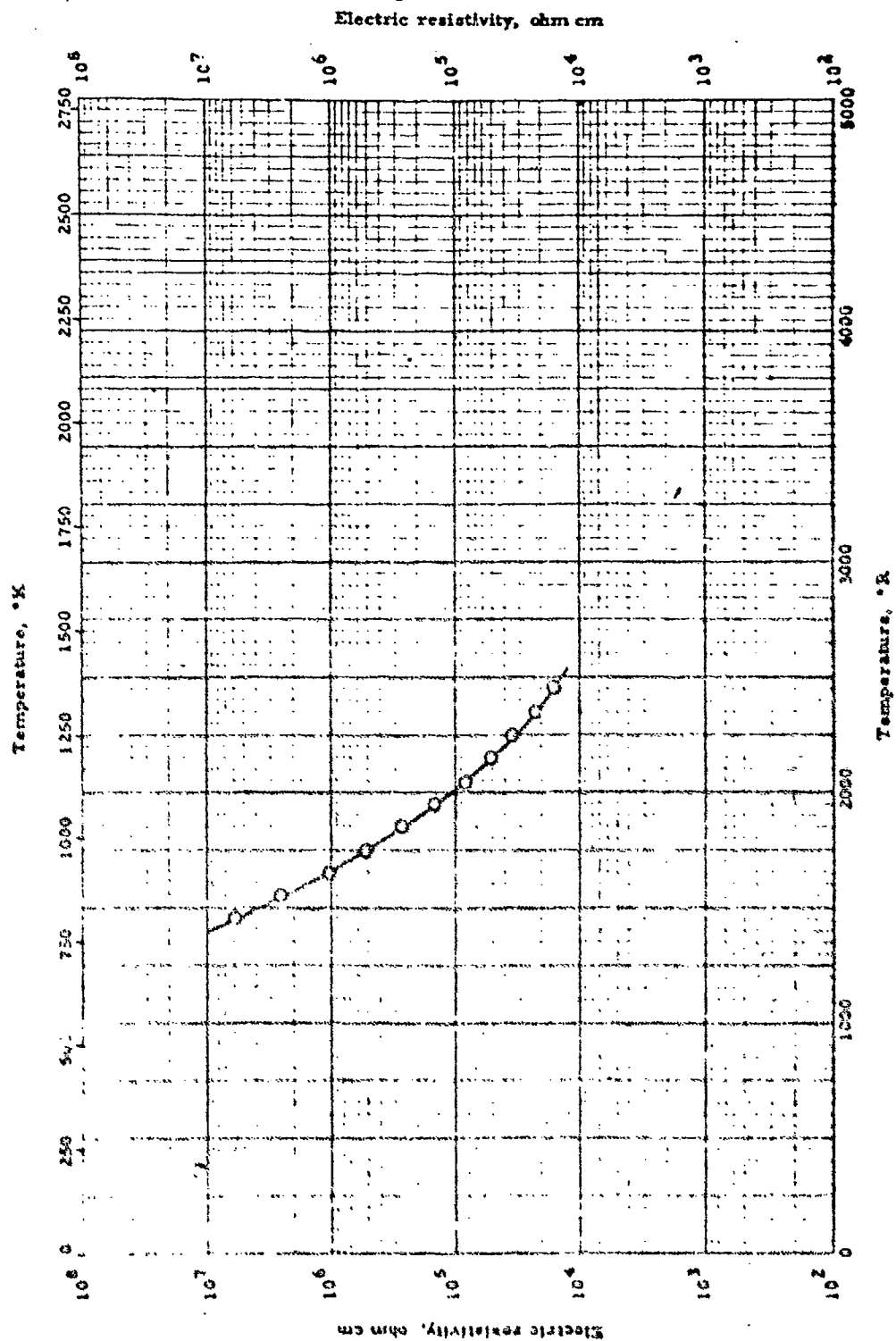


LINEAR THERMAL EXPANSION -- CORDIERITE BODIES

LINEAR THERMAL EXPANSION -- CORDIERITE BODIES

REFERENCE INFORMATION

Ref.	Investigator	Ref. Range, °F	Material Composition	Test Method	Remarks
54-49	Lamar, H. S. and Warner, H. F.	672-2112	50% ZPK; 50% Sierrallite	Quartz tube dilatometer	Fired at 1343°C Absorption not given
54-49	Ibid.	672-2112	Same as above (chlorine)	Same as above	Fired at 1343°C Absorption 1.6%
54-49	Ibid.	672-2112	Same as above	Same as above	Fired at 1316°C Absorption 0.9%
54-49	Ibid.	672-2112	Same as above	Same as above	Fired at 1232°C Absorption 0.0%
54-49	Ibid.	672-2112	Same as above (200 mesh)	Same as above	Fired at 1343°C Absorption 7.5%
54-49	Ibid.	672-2112	Same as above	Same as above	Fired at 1190°C Absorption 6.4%
52-31	Darwin, E. A. and Harman, C. G.	528-1662	Commercial cordierite body	Interferometer	



ELECTRIC RESISTIVITY -- CORDIERITE

59-1118

WADC TR 58-476

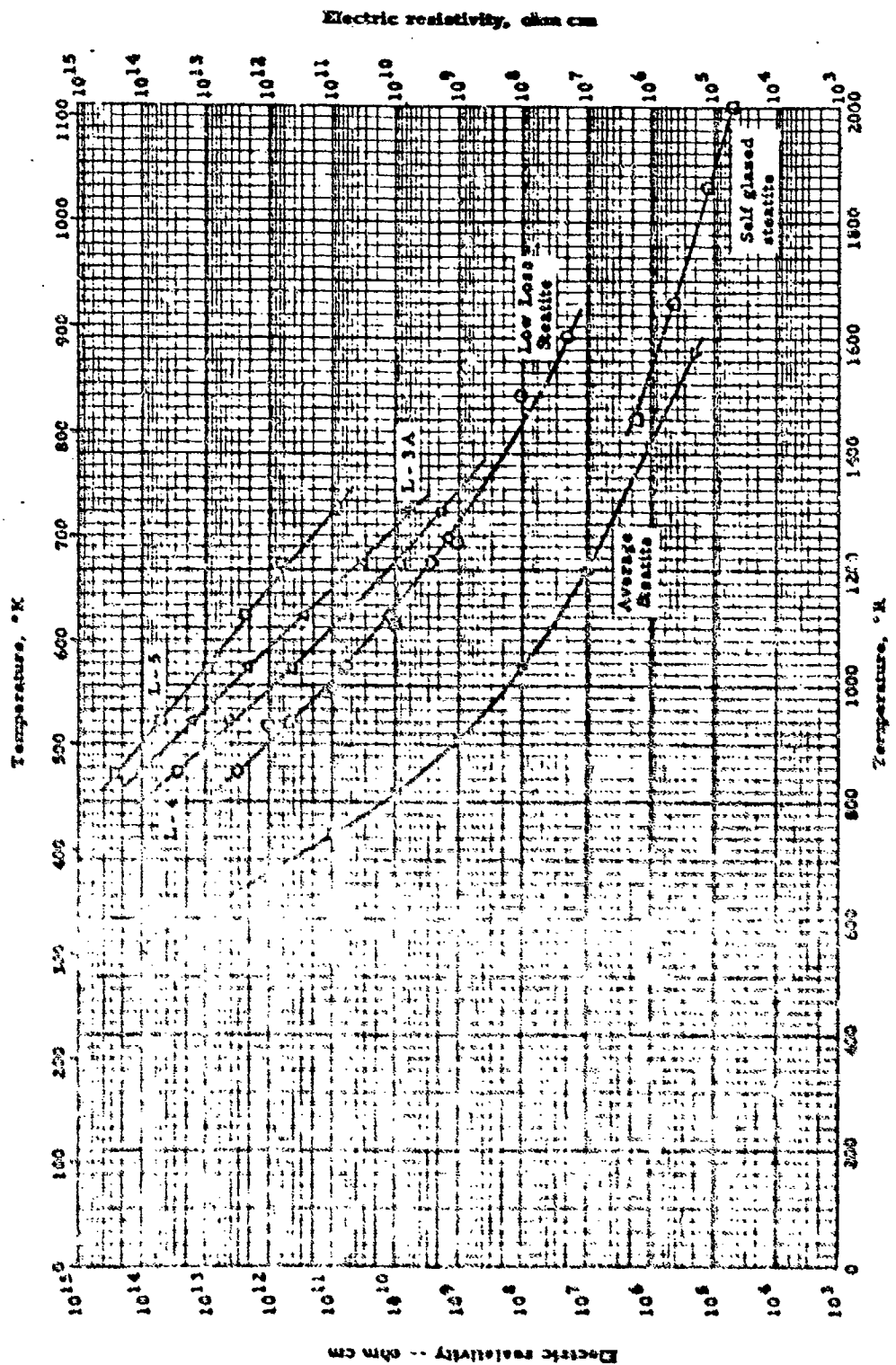
1065

VII - F - 3

ELECTRIC RESISTIVITY -- CORDIERITE

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °C.	Material Composition	Test Method	Remarks
O	Wise, M. R.	57-98	1450-2450	Magnesium aluminosilicate (Cordierite) approx. 51% SiO ₂ ; 15% Al ₂ O ₃ ; 14% MgO	AC impedance bridge; sample temp. by Chromel-Alumel thermocouple	



ELECTRIC RESISTIVITY -- FIRED STEATITE

59-1084

WADC TR 58-476

1067

VI - 2 - 1

ELECTRIC RESISTIVITY -- FIELD TESTS

REFERENCE INFORMATION

Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Connelley, J. E. and Hutch, R. A.	34-95	892-1302	Steel, grade L-4, Al 20mg/100	High resistance DC bridge	
DoD.	34-95	892-1302	Steel, grade L-4, Pb and Sn 20mg/100	Same as above	
DoD.	34-95	892-1302	Cordierite, grade L-2A	Same as above	
DoD.	34-95	892-1302	Cordierite, Al 20mg/100	Same as above	
Frank Jr., M. and Herbert, L. J.	64-6	692-1302	Commercial cordierite, average grade	Potential drop	
DoD.	64-6	912-1402	Commercial ultra-stellite, low loss type	Same as above	

PROPERTIES OF PORCELAIN

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density	210 lb _m /ft ³ *	3.4 g/cm ³ *
Melting Point		
Heat of Fusion		
Heat of Vaporization		
Heat of Sublimation		

*Average value for engineering purposes

REPORTED VALUES

<u>Density:</u>	lb _m /ft ³	g/cm ³
○	212.9 ± 0.6	3.41 ± 0.01
□	181	2.90
△	179	2.87
◇	244	3.91
▽	233	3.68
○	213	3.76
△	230	3.68

<u>Melting Point:</u>	°R	°K
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<u>Heat of Fusion:</u>	Btu/lb _m	cal/g
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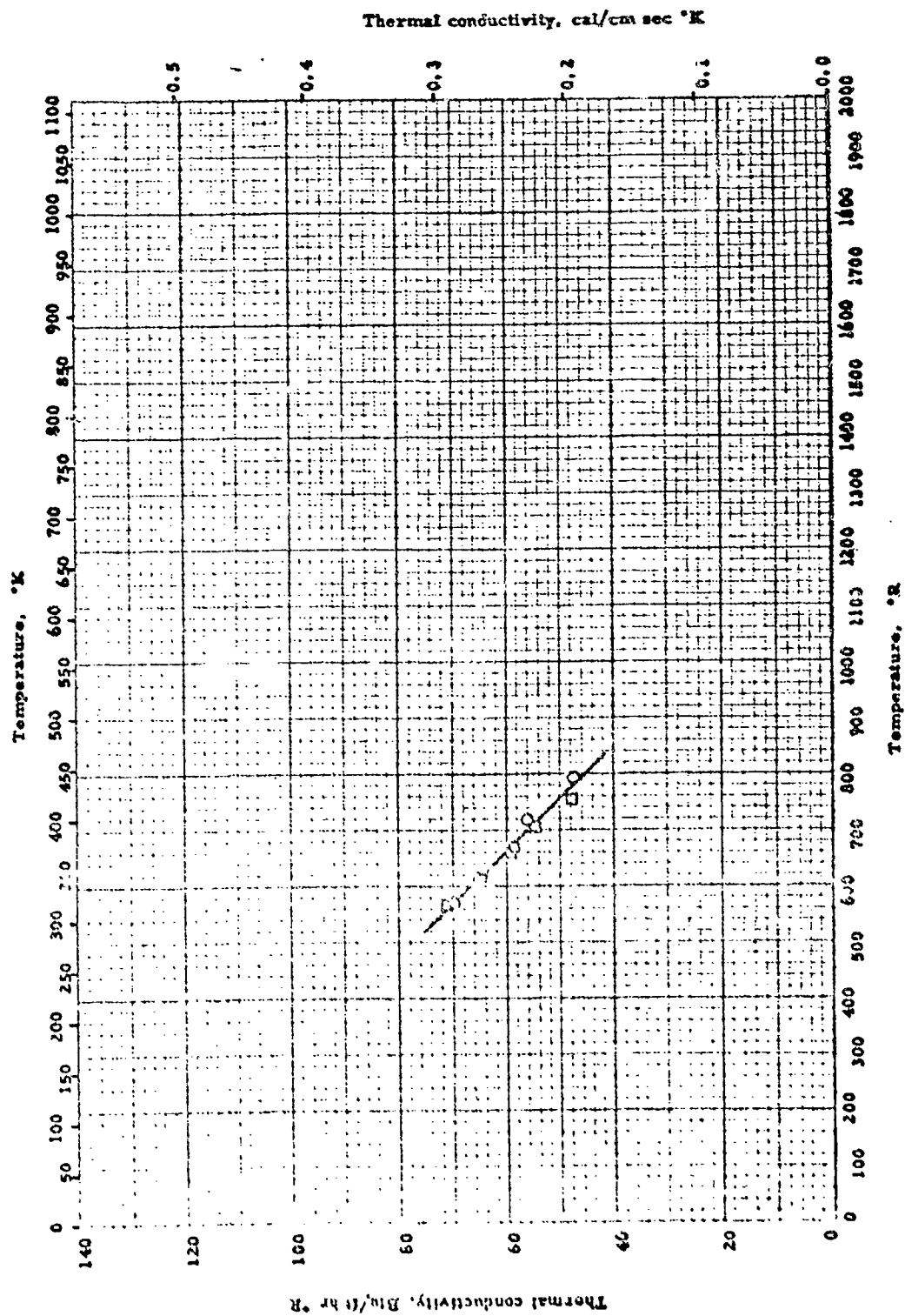
<u>Heat of Vaporization:</u>	Btu/lb _m	cal/g
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<u>Heat of Sublimation:</u>	Btu/lb _m	cal/g
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PROPERTIES OF PORCELAIN

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
○	Oak Ridge National Laboratory	57-150	Porcelain 576	p: weight in air and in kerosene	
□	Koenig, J. H.	53-43 Room	Type 4811 commercial BeO porcelain by Coors; water absorption = 0.09%	Not given	
△	McCreight, L. R.	57-148 Room	Mg titanate porcelain	Not given	
◇	Koenig, J. H.	53-43 Room	High zircon porcelain, 62.5% zircon G; 25% calc. um zirconium silicate; 12.5% Old Mine No. 4 ball clay. Water absorption = 0.05%	Not given	
▽	Pussell Jr., R. and Mohr, W. C.	47-11 Room	Westinghouse zircon porcelain	Not given	
○	Russell Jr., R. and Berberich, L. J.	44-6 Room	Low loss zircon porcelain (above avg. grade)	Not given	
○	Idid.	44-6 Room	Commercial low loss porcelain (avg. grade)	Not given	

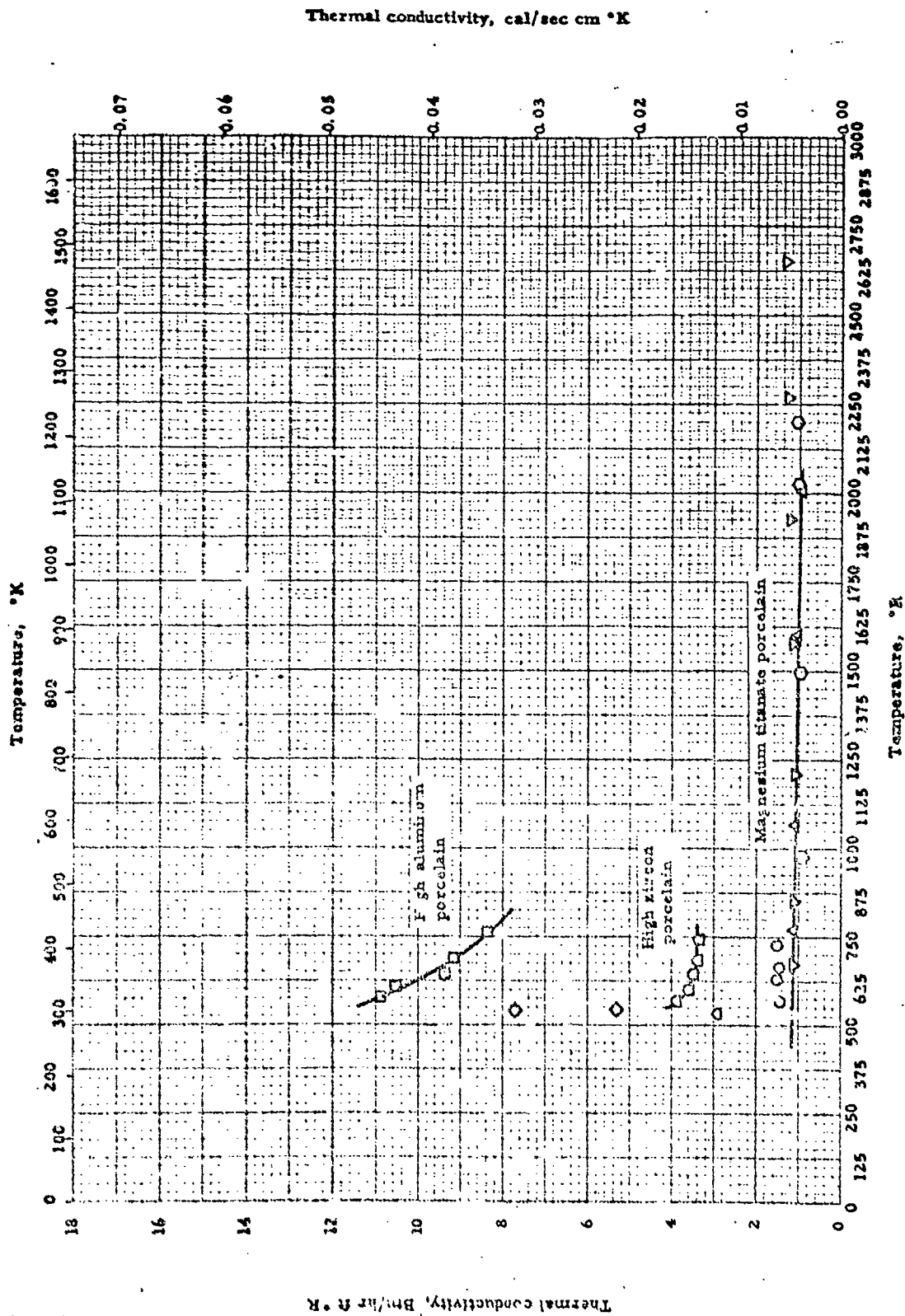


Thermal conductivity -- commercial beryllium oxide porcelain

THERMAL CONDUCTIVITY -- COMMERCIAL BERYLLIUM OXIDE PORCELAIN

REFERENCE INFORMATION

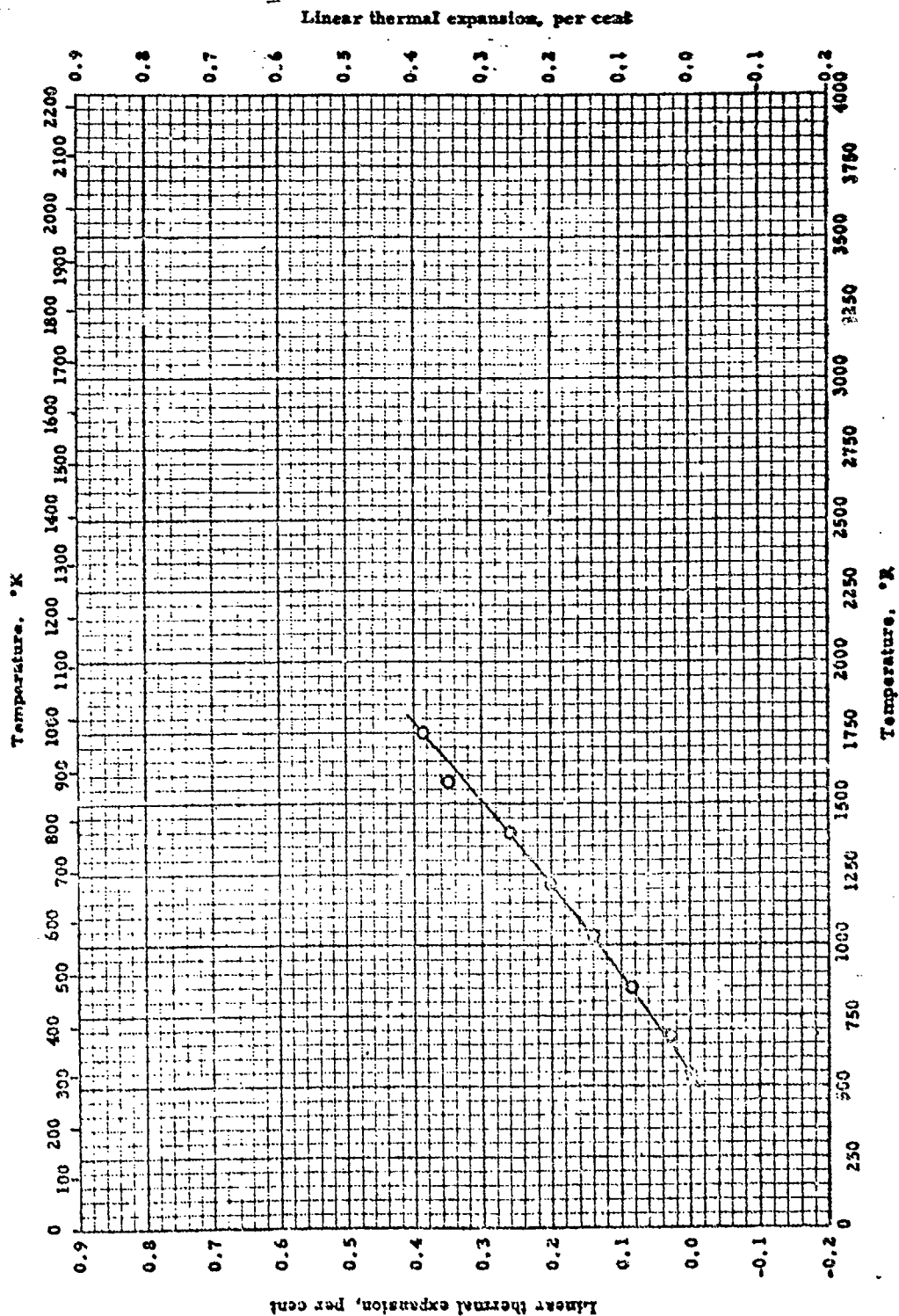
Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O. Kozicki, J. H.	53-43	570-790	Type 4811 commercial BeO porcelain by Coors. $\rho = 181 \text{ lb./ft}^3$; water absorption = 0.09%	Comparative; rods (copper standard)	



THERMAL CONDUCTIVITY -- VARIOUS PORCELAINS

REFERENCE INFORMATION

Investigator	Ref.	Temp., °K.	Material Composition	Test Method	Remarks
○ New Jersey Ceramic Research Station	54-69	573-727	Wet process porcelain No. 7A2	Comparative, rods in vacuum	Pt alloy glaze for ceramic-to-metal bond
○ New Jersey Ceramic Research Station and Koenig, J. H.	53-43	120-305	High alumina porcelain	Comparative, rods in vacuum; incoal standard	
△ McCright, L. R.	57-142	771-2034	Mg titanate porcelain $\rho = 2.87 \text{ g/cm}^3$	Two methods: a. comparative, rods b. axial heat flow in rod; guarded heat source and sample	
○ Oak Ridge National Laboratory	57-150	546	Porcelain 576	Not described here; refers to others	Measured by O. Sisman, C. D. Bopp and R. L. Towns
▽ Kligory, W. D. and French, J.	54-1	472-2652	Electrical porcelain: 37.0% Oxford feldspar; 22.0% Edgar Nocavil clay; 19.0% flint; 15.0% Kentucky Old Mine No. 4 ball clay; 7.0% Edgar plastic kaolin	Ellipsoidal envelope	Ball milled 15 hr., slip cast, fired at 1250°C to zero apparent porosity
○ Klasse, F., Heinz, A. and Hein, J.	57-181	937-2157	Electrical porcelain	Comparative, disks, with guard cylinder. Temp. by thermocouple	Data of low accuracy
○ Koenig, J. H.	53-43	560-740	High zircon porcelain. 62.5% zircon G; 25% calcium zirconium silicate; 12.5% Old Mine No. 4 ball clay. $\rho = 244 \text{ lb}_m/\text{ft}^3$. Water absorption = 0.03%	Comparative; rods (copper standard)	
○ Russell Jr., R. and Mohr, W. C.	47-11	Room	Westinghouse zircon porcelain. $\rho = 230 \text{ lb}_m/\text{ft}^3$	Not given	



LINEAR THERMAL EXPANSION -- ELECTRICAL PORCELAIN

59-244

WADC TR 58-476

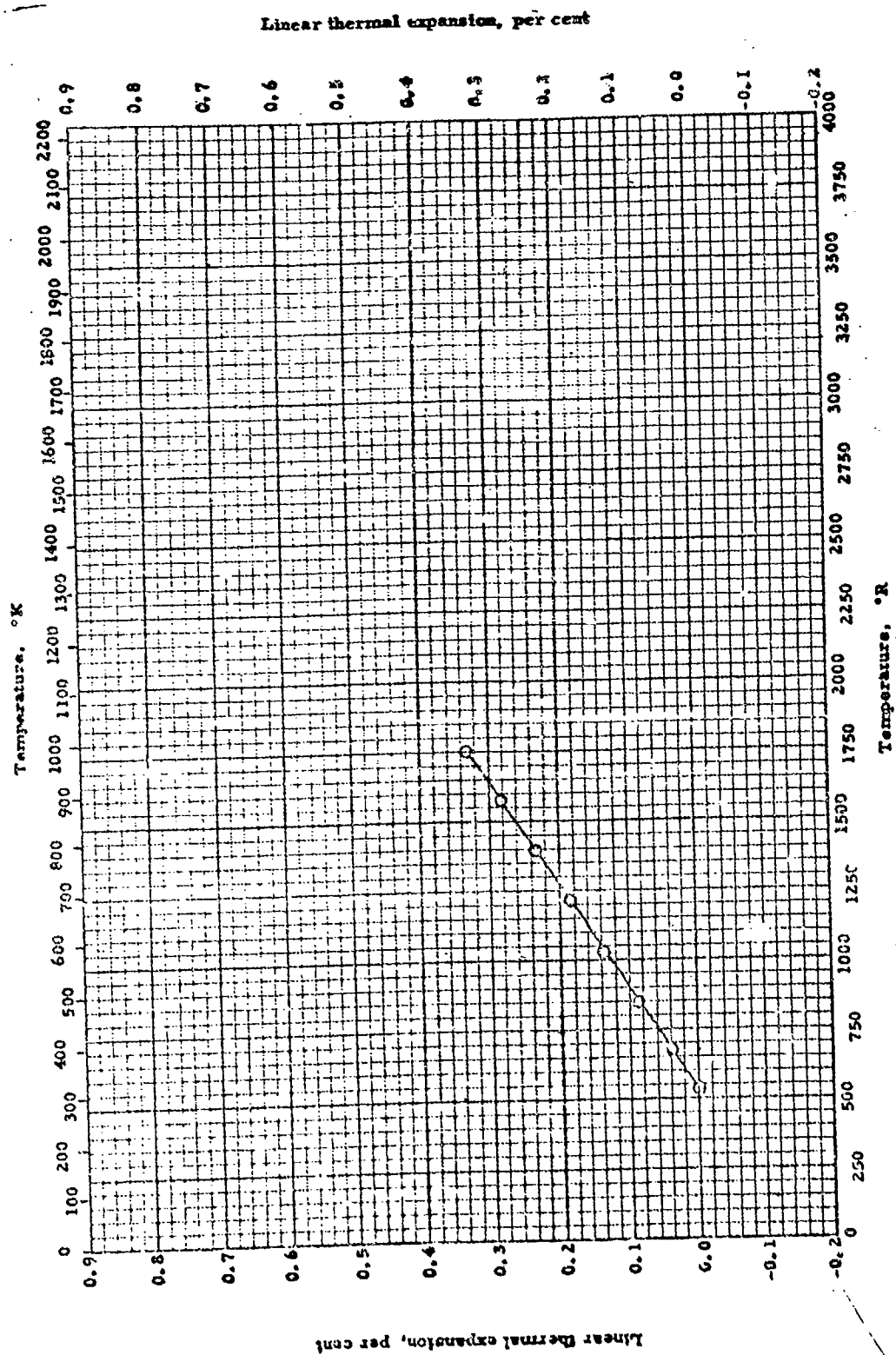
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VII - E - 4

LINEAR THERMAL EXPANSION -- ELECTRICAL PORCELAIN

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Herman, C. G.	52-31	528-1752	Not given	Interferometer	



LINEAR THERMAL EXPANSION -- ZIRCON PORCELAIN

VII - E - 4

59-572

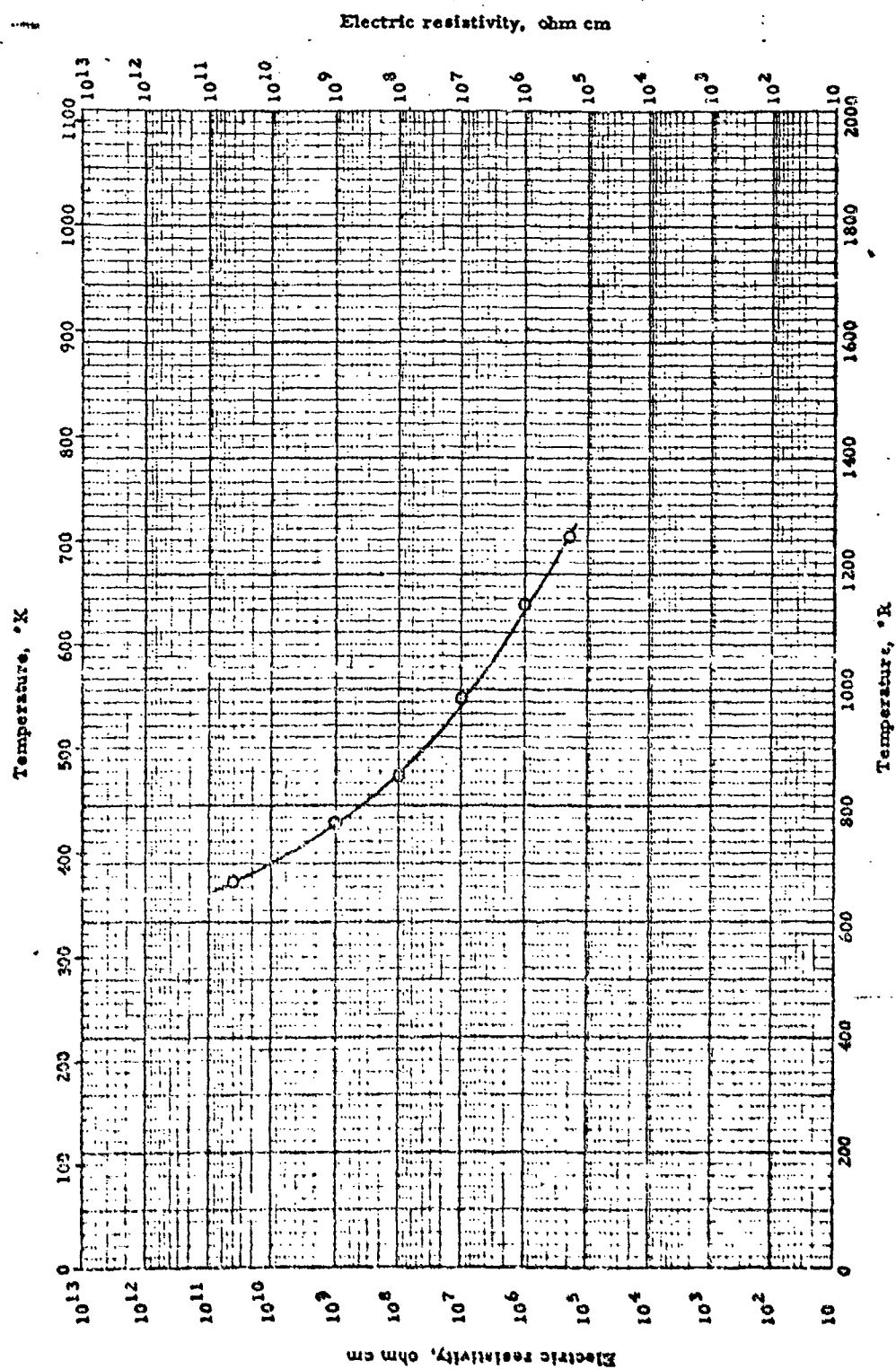
WADC TR 58-476

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LINEAR THERMAL EXPANSION -- ZIRCON PORCELAIN

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Russell, Jr., R. and Mohr, W. C.	47-11	528-1752	Westinghouse Zircon Porcelain; $\rho = 230 \text{ lb}_m/\text{ft}^3$	Not given	



ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, HIGH TENSION

59-1044

WADC TR 58-476

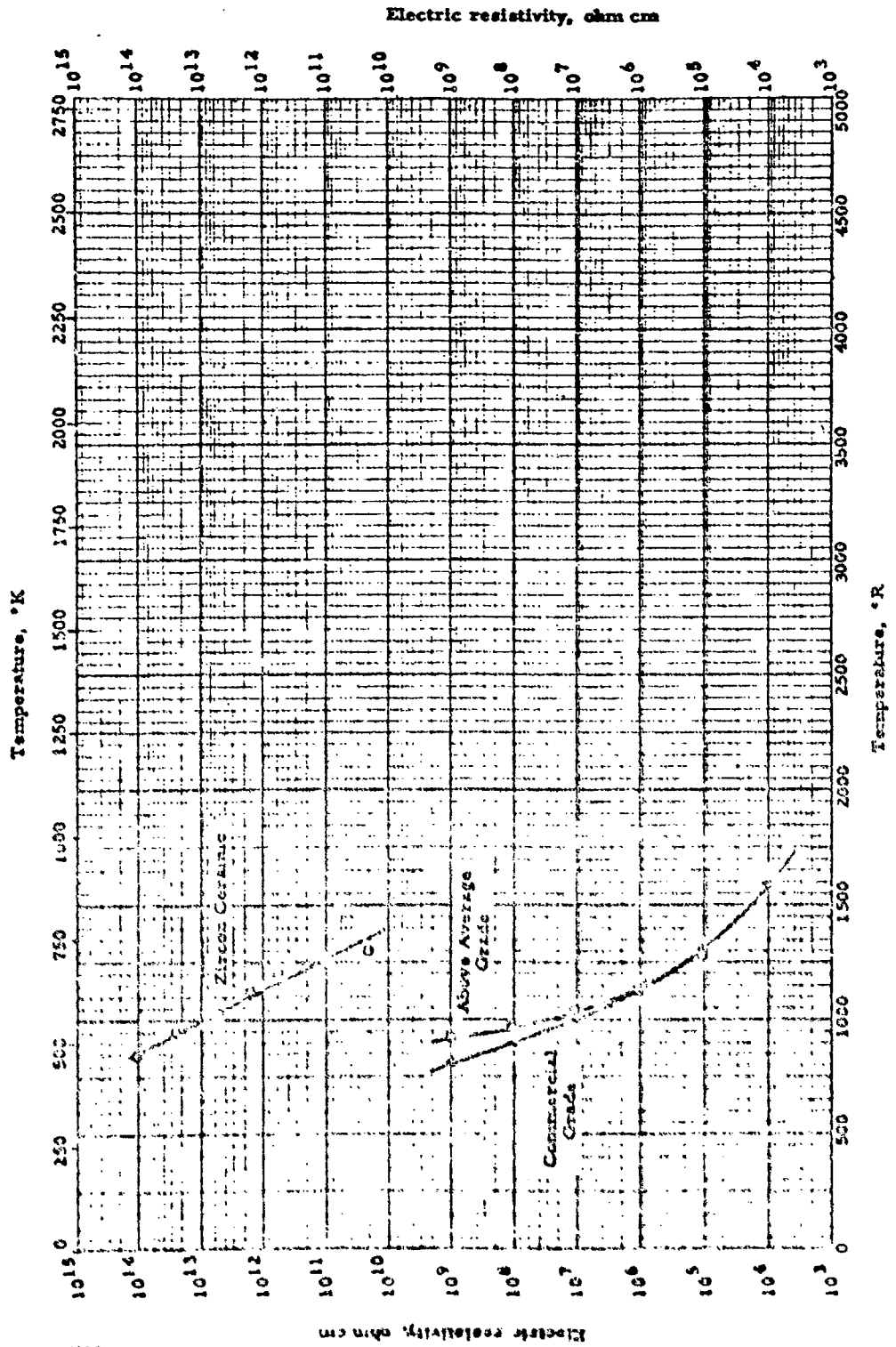
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VII - K - 4

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, HIGH TENSION

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Russel Jr., R. and Herberich, L.J.	44-6	672-1266	Commercial high-tension electrical porcelain	AC impedance bridge	Density 150 lb./ft. ³



89-1108

WADC TR 58-476

1081

VA - 3 - 4

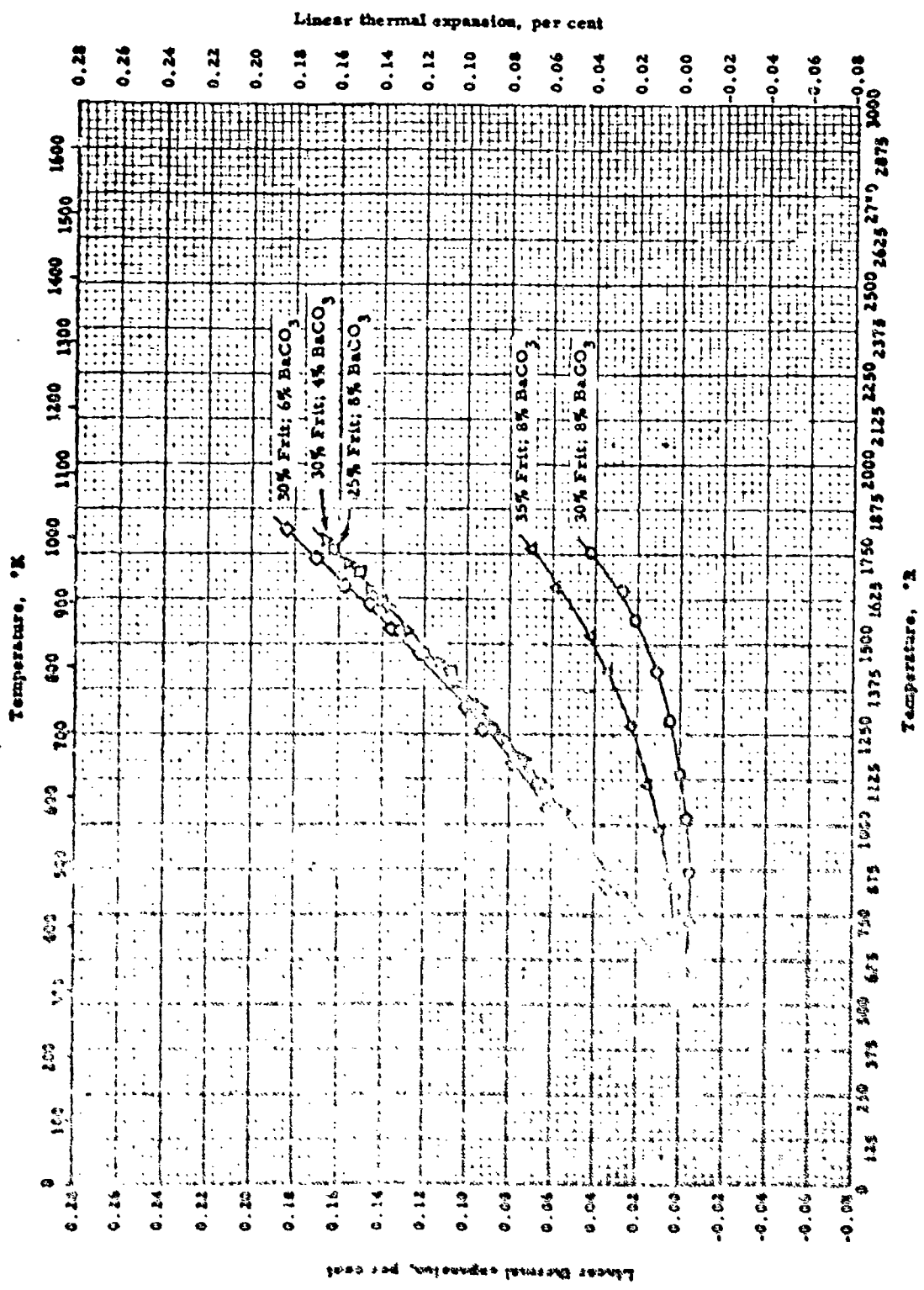
ELECTRIC RESISTIVITY -- ZIRCON PORCELAIN

REFERENCE INFORMATION

Investigator	Ref.	Range, °K.	Material Composition	Test Method	Remarks
Cummins, J. E. and Mead, R. A.	34-93	852-1202	12.52% silicon; 30.0% CaZr silicate; 12.5% BaZr silicate; 7.5% MgZr silicate; 25% Old Mine No. 4 clay; 17.5% EPK	DC reversal	
Cummins Jr., R. and Marbach, L. J.	44-6	924-1662	Low loss silicon porcelain (above avg. grade)	Bridge method and potential drop at lower resistivities	$\rho = 235 \text{ lb}_m/\text{ft}^3$
Edm.	46-6	816-1590	Commercial low loss porcelain, avg. grade	Same as above	$\rho = 230 \text{ lb}_m/\text{ft}^3$

59-780
WALC LR 58-676 1003

9-3-74



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(25 - 35% Frit Level)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE EODIES, BARIUM MODIFIED
(25 - 35% Frit Level)

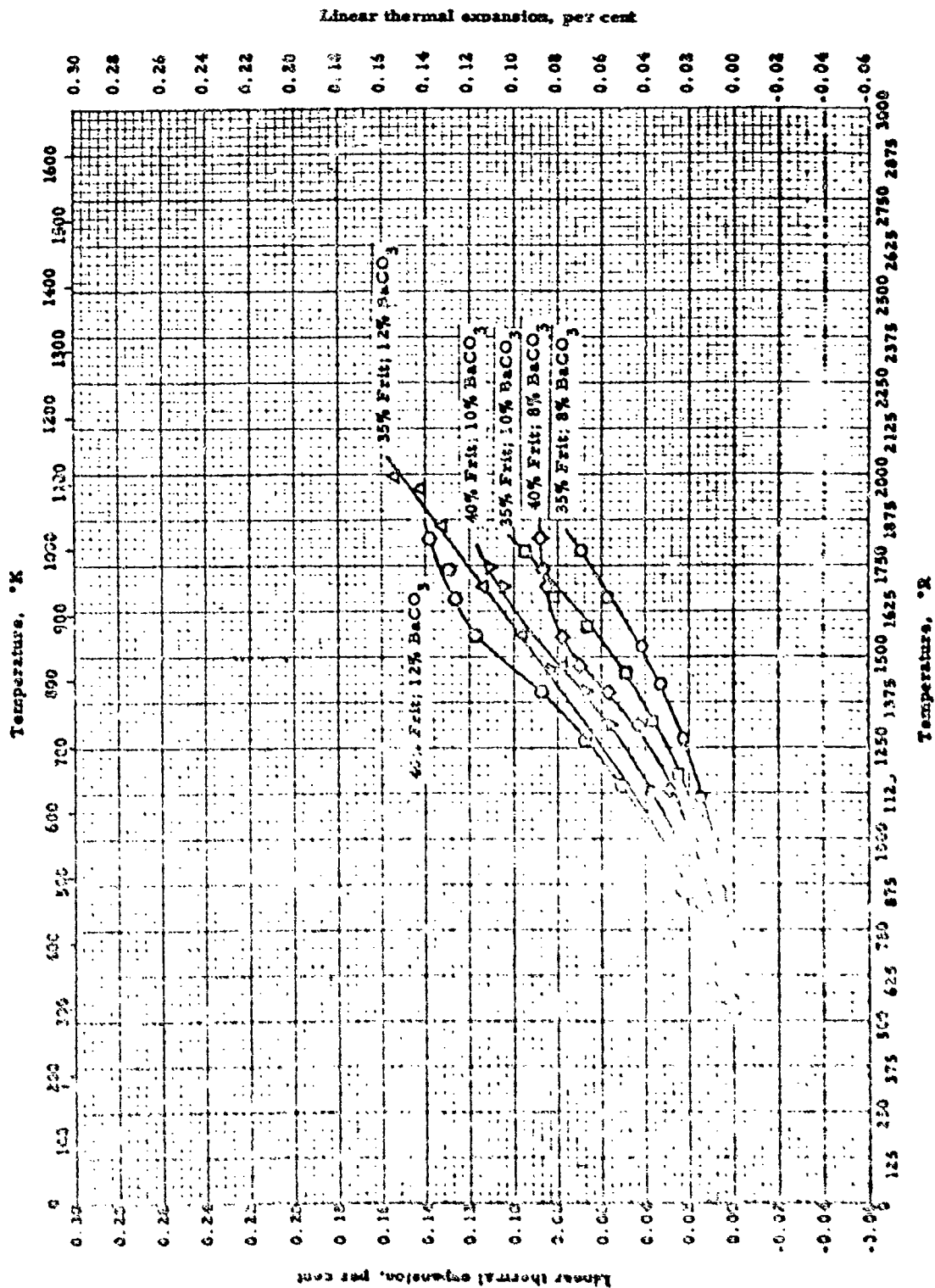
REFERENCE INFORMATION

Ref	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koenig, J. H.	53-43	528-1757	62% E.P.K. clay; 30% QC6 frit; 8% BaCO ₃	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is made from Li ₂ CO ₃ V.P.K. clay, and flint
□	Ibid.	53-43	528-1764	67% E.P.K. clay; 25% QC6 frit; 8% BaCO ₃	Same as above	Same as above
△	Ibid.	53-43 also 53-5	528-1793	57% E.P.K. clay; 35% QC6 frit; 8% BaCO ₃	Same as above	Same as above
◇	Ibid.	53-43	528-1822	64% E.P.K. clay; 30% QC6 frit; 6% BaCO ₃	Same as above	Same as above
▽	Ibid.	53-43	528-1780	66% E.P.K. clay; 30% QC6 frit; 4% BaCO ₃	Same as above	Same as above

119-611

WADC TR 56-476

1085



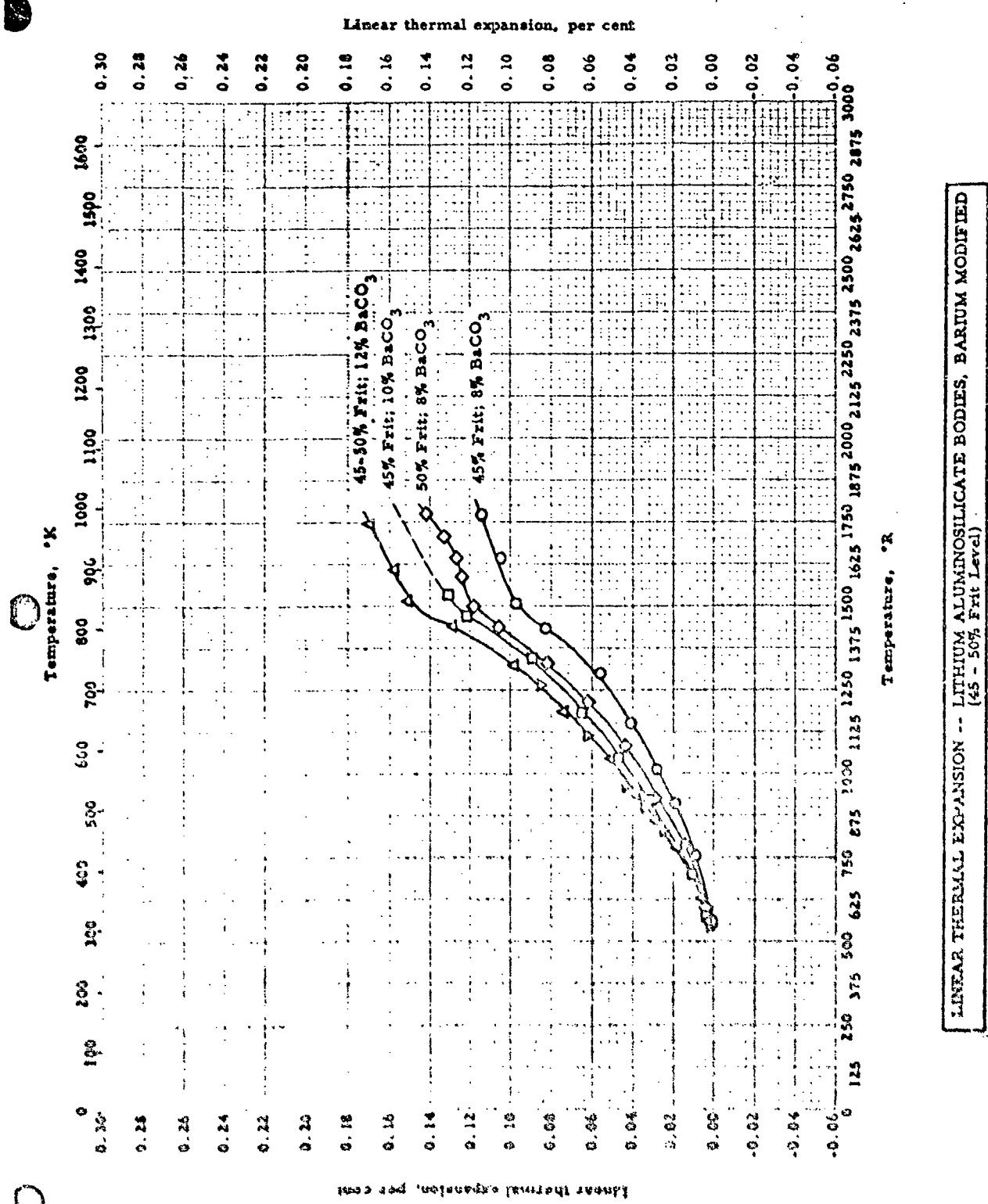
VII - E - 6

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINO-SILICATE BODIES, BARIUM MODIFIED
(35% Frit; 10% BaCO₃)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(35 - 40% Frit Level)

REFERENCE INFORMATION

Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○ New Jersey Ceramic Research Station	52-5 Also 53-43	562-1793	57% clay (No. 4 Blend); 35% QC6 frit; 8% BaCO ₃	Fused silica tube dilatometer	Matured at 2200°F. Frit by a an oxide analysis of 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is prepared from Li ₂ CO ₃ , E.P.K. clay and flint. No. 4 Blend clay is from United Clay Mines Corp. Same as above
○ Ibid.	53-5	564-1781	55% clay (No. 4 Blend); 35% QC6 frit; 10% BaCO ₃	Same as above	Matured at 1800°F; rest same as above
△ Ibid.	53-5	550-1991	55% clay (No. 4 Blend); 35% QC6 frit; 12% BaCO ₃	Same as above	Matured at 2000°F; rest same as above
○ Ibid.	53-5	566-1828	52% clay (No. 4 Blend); 40% QC6 frit; 8% BaCO ₃	Same as above	Matured at 1940°F; rest same as above
▽ Ibid.	53-5	562-1743	50% clay (No. 4 Blend); 40% QC6 frit; 10% BaCO ₃	Same as above	Matured at 1800°F; rest same as above
○ Ibid.	53-5	566-1824	45% clay (No. 4 Blend); 40% QC6 frit; 15% BaCO ₃	Same as above	Matured at 1800°F; rest same as above



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES. BARIUM MODIFIED
(45 - 50% Frit Level)

REFERENCE INFORMATION

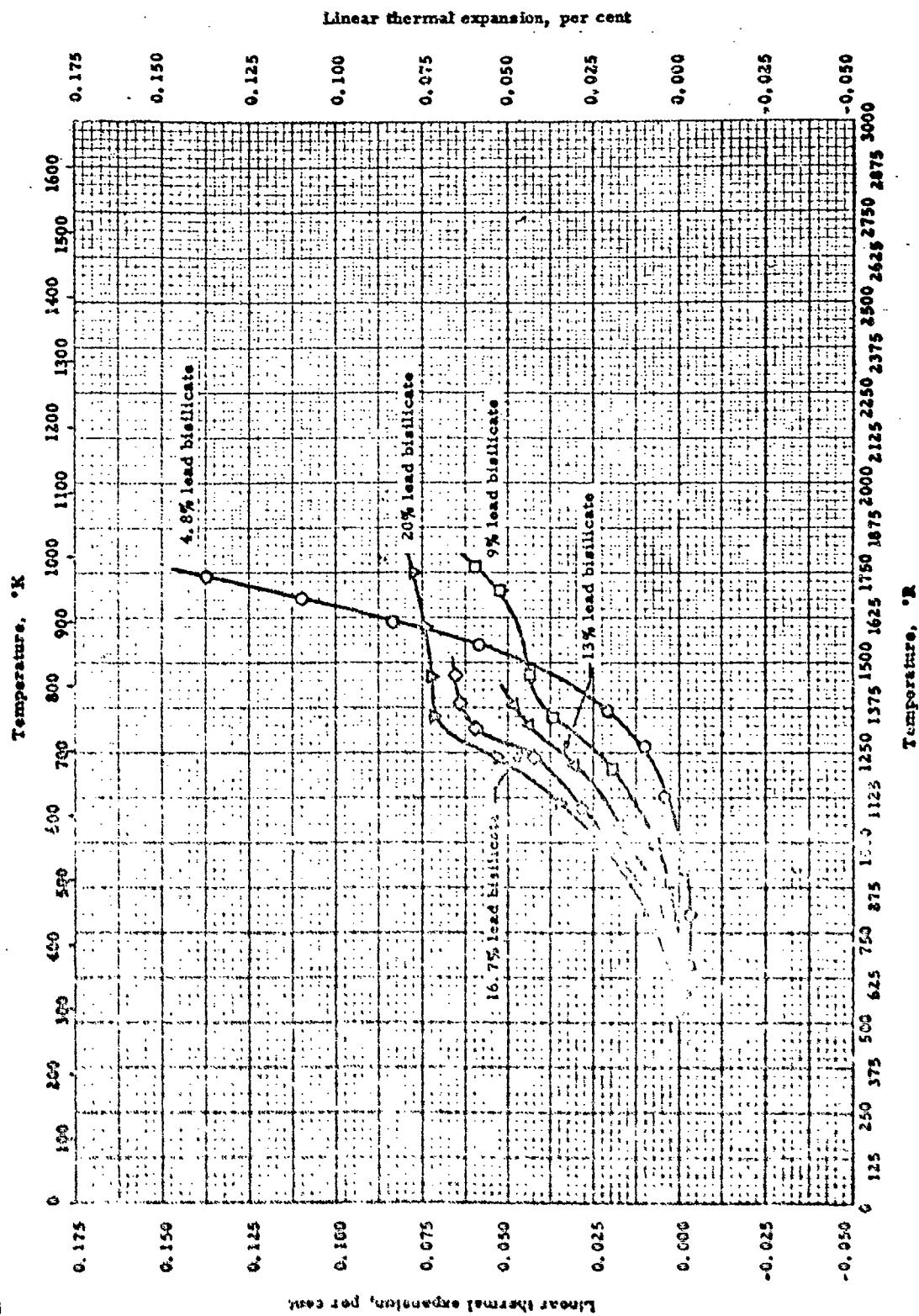
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○ New Jersey Ceramic Research Station	53-5	564-1772	47% clay (No. 4 Blend); 45% QC6 frit; 8% BaCO ₃	Fused silica tube dilatometer	Matured at 1880°F. QC6 frit has an oxide analysis of 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is prepared from Li ₂ CO ₃ ; E.P.K. clay; and flint. No. 4 Blend clay is from United Clay Mines Corp.
□ T64.	53-5	573-1534	45% clay (No. 4 Blend); 45% QC6 frit; 10% BaCO ₃	Same as above	Matured at 1780°F; rest same as above
△ T64.	53-5	566-1767	45% QC6 frit; 43% clay (No. 4 Blend); 12% BaCO ₃	Same as above	Same as above
○ T64.	53-5	566-1777	50% QC6 frit; 42% clay (No. 4 Blend); 8% BaCO ₃	Same as above	Matured at 1880°F; rest same as above
▽ T64.	53-5	566-1268	50% QC6 frit; 33% clay (No. 4 Blend); 12% BaCO ₃	Same as above	Matured at 1780°F; rest same as above

59-410

WADC TR 58-476

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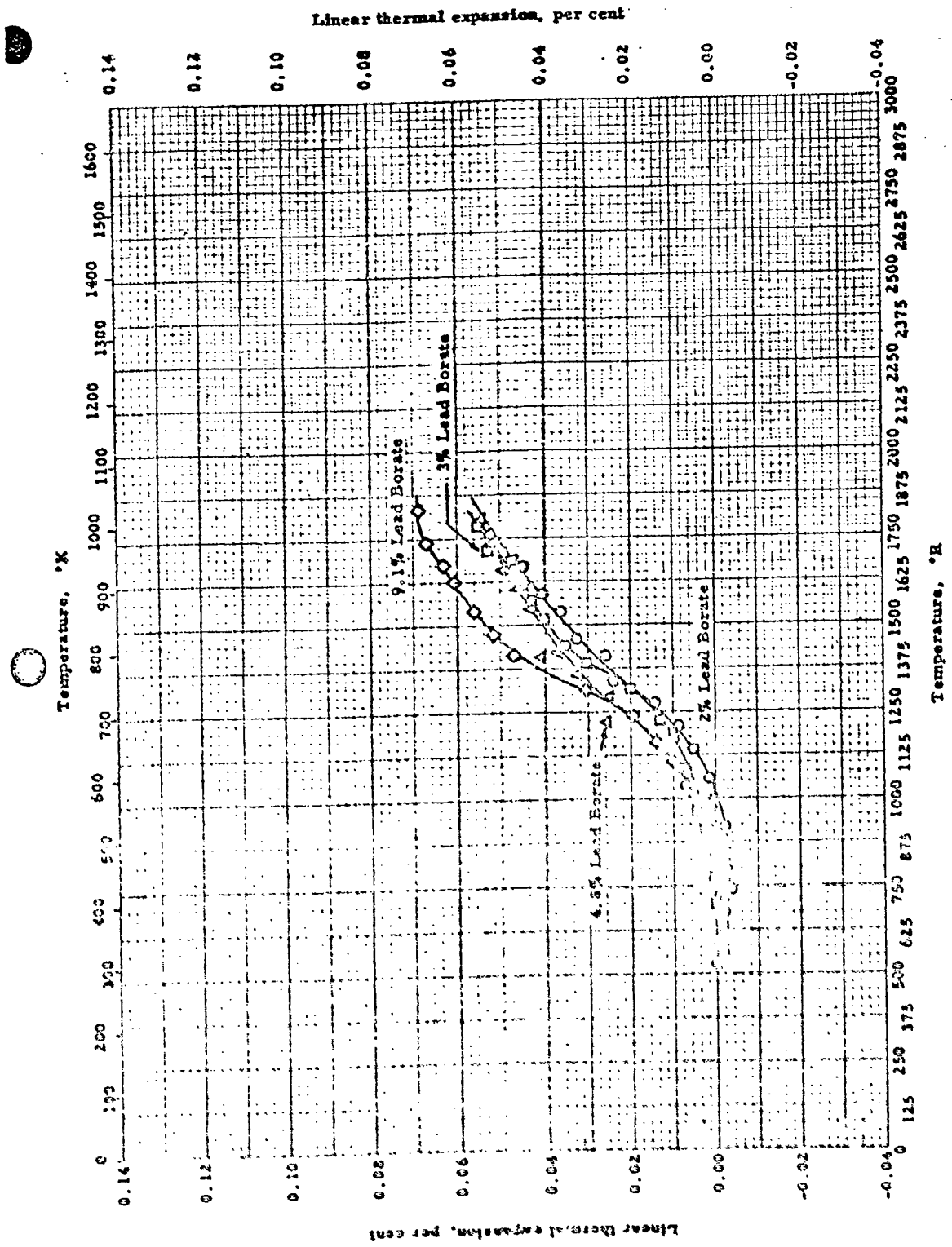
VII - K - 6



**LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE
WITH LEAD BISILICATE**

REFERENCE INFORMATION

Specimen	Tag	Range, °F	Material Composition	Test Method	Remarks
Q	53-43	528-1743	56.1% QC6 frit; 37.1% E.P.K. clay; 4.8% lead bisilicate	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is made from Li ₂ CO ₃ , E.P.K. clay, and flint
Q	53-43	528-1766	55.5% QC6 frit; 35.5% E.P.K. clay; 9% lead bisilicate	Same as above	Same as above
A	53-43	528-1384	53.0% QC6 frit; 33.9% E.P.K. clay; 13% lead bisilicate	Same as above	Same as above
Q	53-43	528-1460	50.8% QC6 frit; 32.5% E.P.K. clay; 16.7% lead bisilicate	Same as above	Same as above
V	53-43	528-1750	48.8% QC6 frit; 31.2% E.P.K. clay; 20% lead bisilicate	Same as above	Same as above



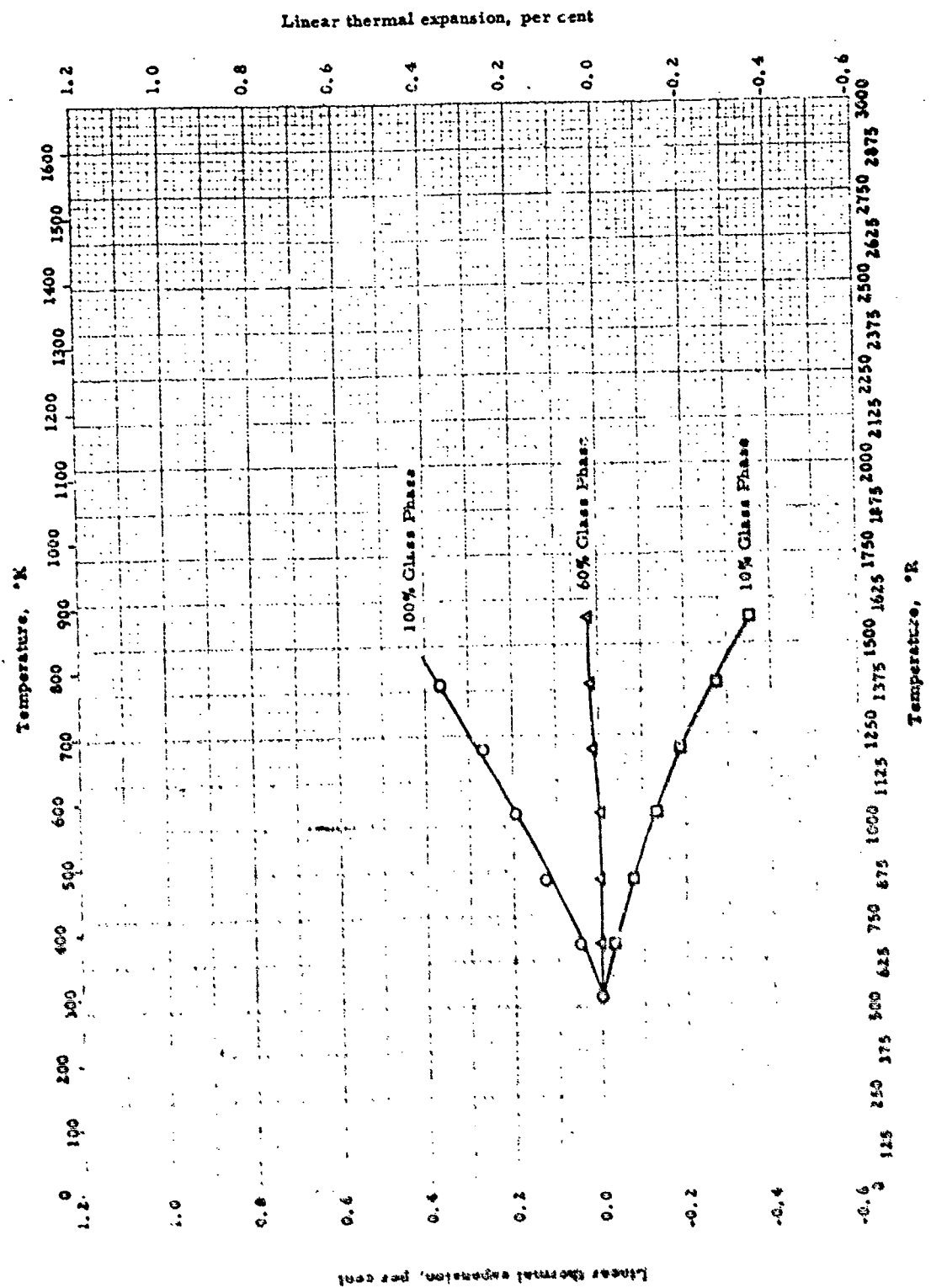
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LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE WITH LEAD BORATE

**LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE
WITH LEAD BORATE**

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
53-43	Koenig, J. H.	53-43	528-1759	59.8% QC6 frit; 39.2% E. P. K. clay; 2% lead borate	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is made from Li ₂ CO ₃ , E. P. K. clay, and flint
53-43	Ibid.	53-43	528-1784	59.2% QC6 frit; 37.9% E. P. K. clay; 3% lead borate	Same as above	Same as above
53-43	Ibid.	53-43	528-1809	58.1% QC6 frit; 37.1% E. P. K. clay; 4.8% lead borate	Same as above	Same as above
53-43	Ibid.	53-43	528-1834	55.5% QC6 frit; 35.4% E. P. K. clay; 9.1% lead borate	Same as above	Same as above



59-472
WADC TR 58-476 1093

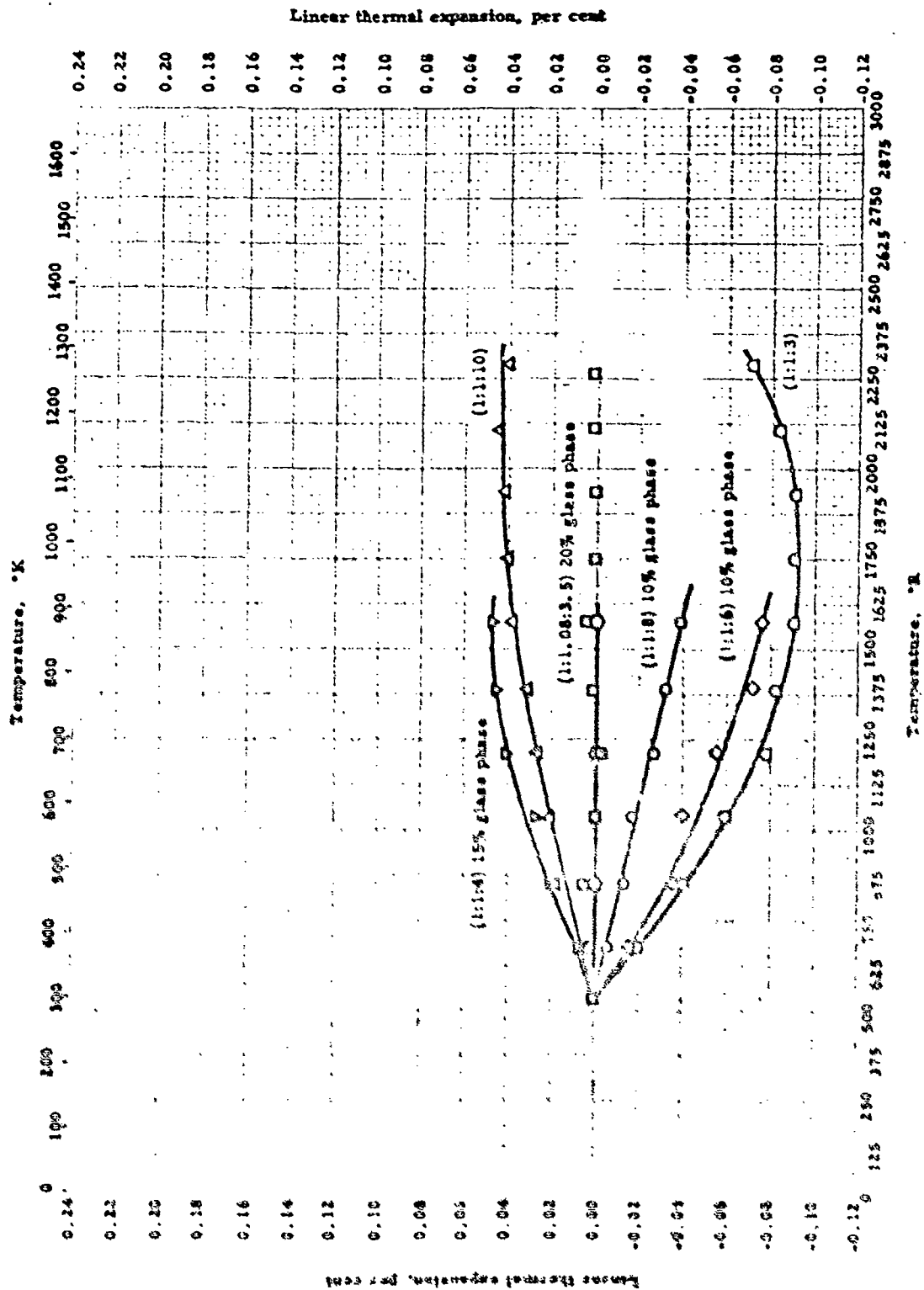
VII - 3 - 6

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:2)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:2)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Avgerinakis, A. and Vasiliev, E. I.	55-27	528-1392	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$; 100% glass	Dilatometer	Fired 1 hr. at 1450°C
△	ibid.	55-27	528-1392	Same as above; 40% crystals of en- cryptite; 60% glass	Same as above	Fired 1 hr. at 1150°C
□	ibid.	55-27	528-1392	Same as above; 90% crystals of en- cryptite; 10% glass	Same as above	Fired 1/2 hr. at 1150°C

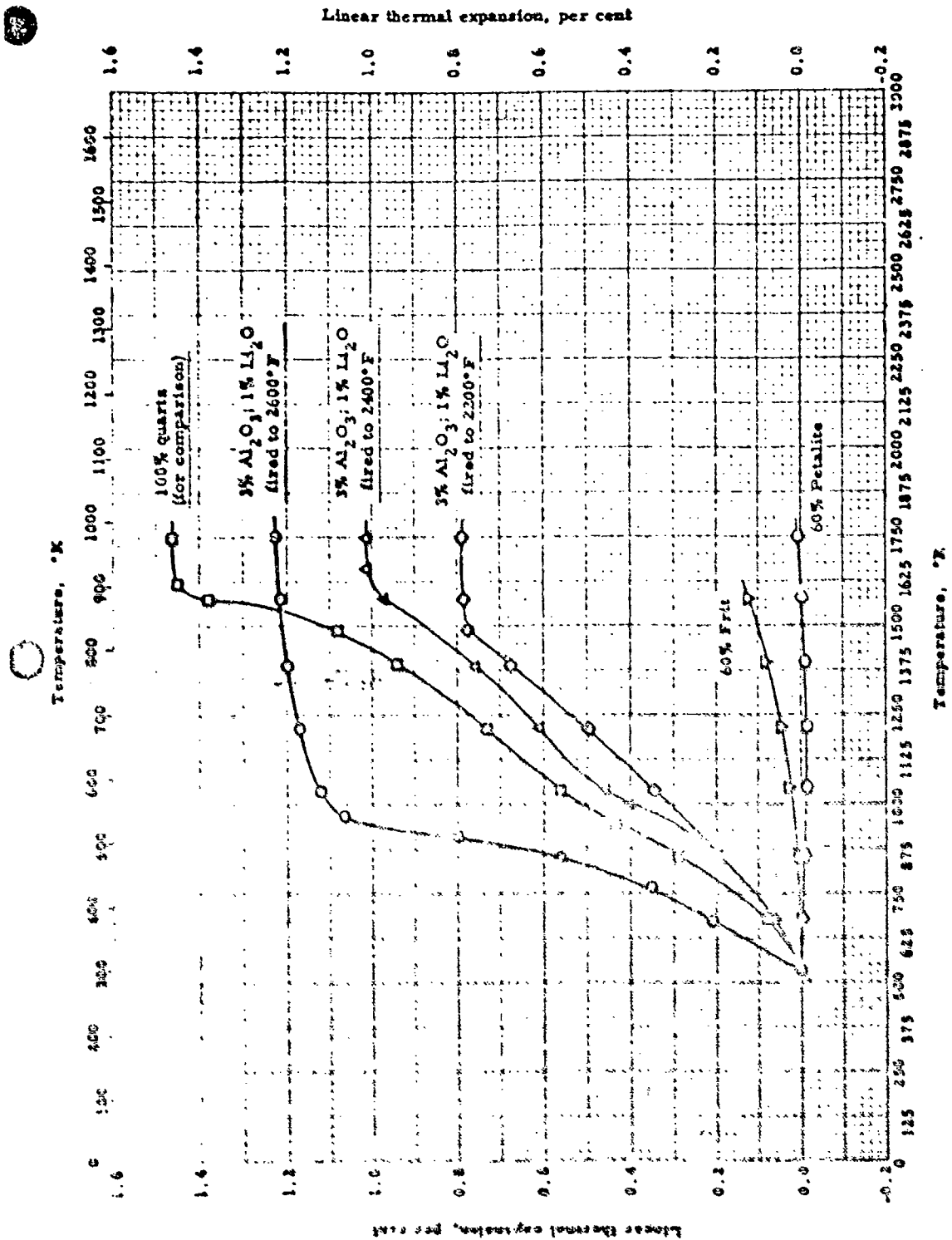


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:3 to 10)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:3 to 10)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Arguevalle, A. and Vassil'ev, E. I.	55-27	528-1572	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$; 85% petalite; 15% $\alpha\text{-Al}_2\text{O}_3$; 10% glass phase	Dilatometer	Fired 1/2 hr. at 1150°C
□	Hammond, F. A.	51-21	528-2292	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$; petalite prepared from c.p. Li_2CO_3 -p. Al_2O_3 ; 2% binder	Dilatometer	Pressed 100 mesh calcined material at 1000 lb/in. ² with binder
△	Idid.	51-21	528-2292	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 10\text{SiO}_2$; prepared from c.p. Li_2CO_3 ; c.p. Al_2O_3 ; potter's glaze	Dilatometer	Pressed 100 mesh calcined material at 1000 lb/in. ² with binder
○	Arguevalle, A. and Vassil'ev, E. I.	55-27	528-1572	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$; 90% crystals; 10% glass phase	Dilatometer	Fired 1/2 hr. at 1150°C
▽	Idid.	55-27	528-1572	$\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$; 80% crystals of $\alpha\text{-Li}_2\text{SiO}_3$; 15% glass; 5% not given	Dilatometer	Fired 1/2 hr. at 1150°C
○	Idid.	55-27	528-1572	$\text{Li}_2\text{O} \cdot 1.68\text{Al}_2\text{O}_3 \cdot 1.5\text{SiO}_2$; 80% crystals of eucryptite; 20% glass	Same as above	Same as above
○	Hammond, F. A.	51-21	528-2292	$\text{Li}_2\text{O}_2 \cdot \text{Al}_2\text{O}_3 \cdot 16\text{SiO}_2$; prepared from c.p. Li_2CO_3 ; c.p. Al_2O_3 ; potter's glaze	Dilatometer	Pressed from 100 mesh calcined material at 1000 lb/in. ² with binder

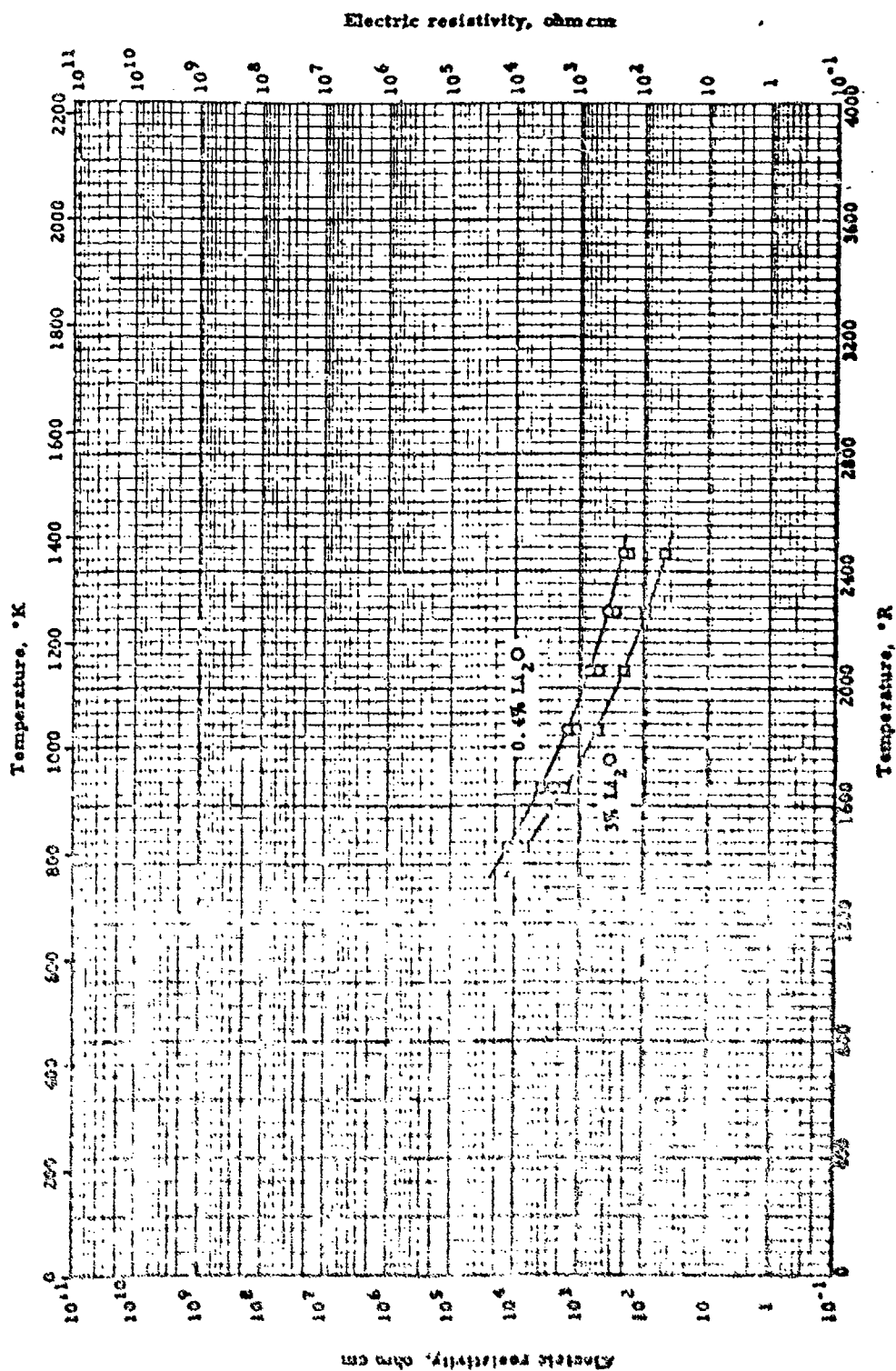


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE

REFERENCE INFORMATION

Ref.	Investigator	Range, °F	Material Composition	Test Method	Remarks
54-43	Smoke, E. J.	528-1752	90% SiO ₂ ; 3% Al ₂ O ₃ ; 1% Li ₂ O; prepared from E. P. K. clay, flint, Li ₂ CO ₃	Fused silica tube dilatometer	Fired in 5 hr. to 2600°F, soaked 1 hr.
54-43	Ibid.	528-1752	Same as above	Same as above	Fired in 5 hr. to 2400°F, soaked 1 hr.
54-43	Ibid.	528-1752	Same as above	Same as above	Fired in 5 hr. to 2200°F, soaked 1 hr.
54-43	Ibid.	528-1752	100% SiO ₂ quartz (for comparison purposes)	Same as above	Same as above
53-44	New Jersey Ceramic Research Station	528-1572	59.8% QC6 frit; 38.2% E. P. K. clay; 2% MgCO ₃	Fused silica tube dilatometer	QC6 frit has oxide composition of 80% SiO ₂ ; 12% Li ₂ O; 8% Al ₂ O ₃ and is prepared from Li ₂ CO ₃ , E. P. K. clay and flint
53-44	Ibid.	528-1752	60% Petalite; 24.4% QC6 frit; 15.6% E. P. K. clay	Same as above	Same as above



ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LITHIUM MODIFIED

59-1134

WADC TR 58-476

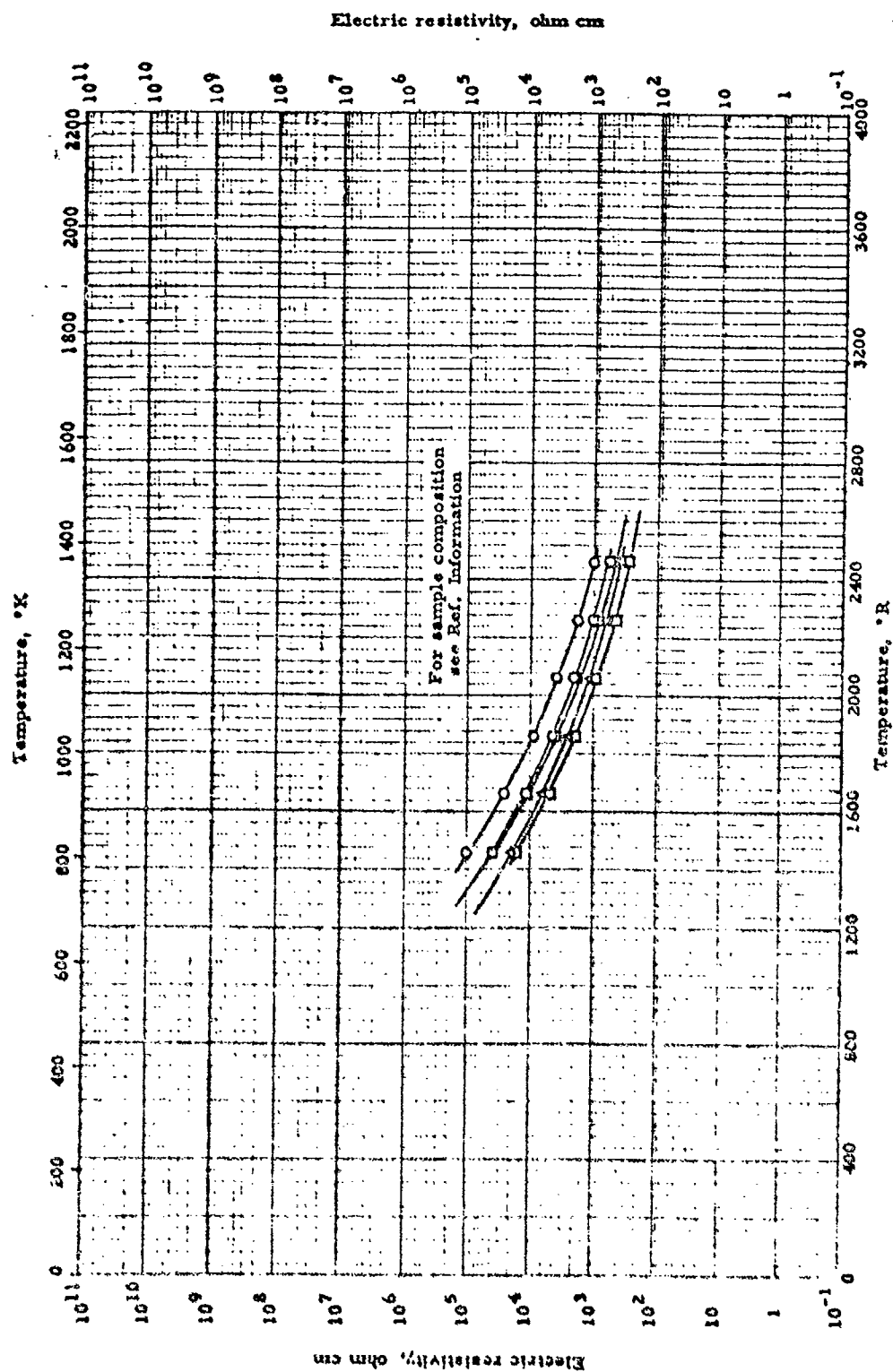
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9 - 3 - 1A

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LITHIUM MODIFIED

REFERENCE INFORMATION

	Investigator	Zcf.	Range, °R	Material Composition	Test Method	Remarks
○	Wisely, H. R.	57-98	1460-2460	Li-K body series: 1, 2a, 2b, 2c, 2d, 2e; nominal range: 62.2-75.5% SiO ₂ , 21.6-35.5% Al ₂ O ₃ , 1.8-2.8% (K, Na) ₂ O; 0.4-0.7% Li ₂ O	AC Impedance bridge; Chromel-Alumel thermo- couple	Fired at 2200-2550°F
□	Ibid.	57-98	1460-2460	Petalite body; nominal: 76.0% SiO ₂ , 21.0% Al ₂ O ₃ , 3.0% Li ₂ O	Same as above	Fired at 2400°F. Formed from 30% petalite and 50% clay



59-11126

WADC TR 58-476

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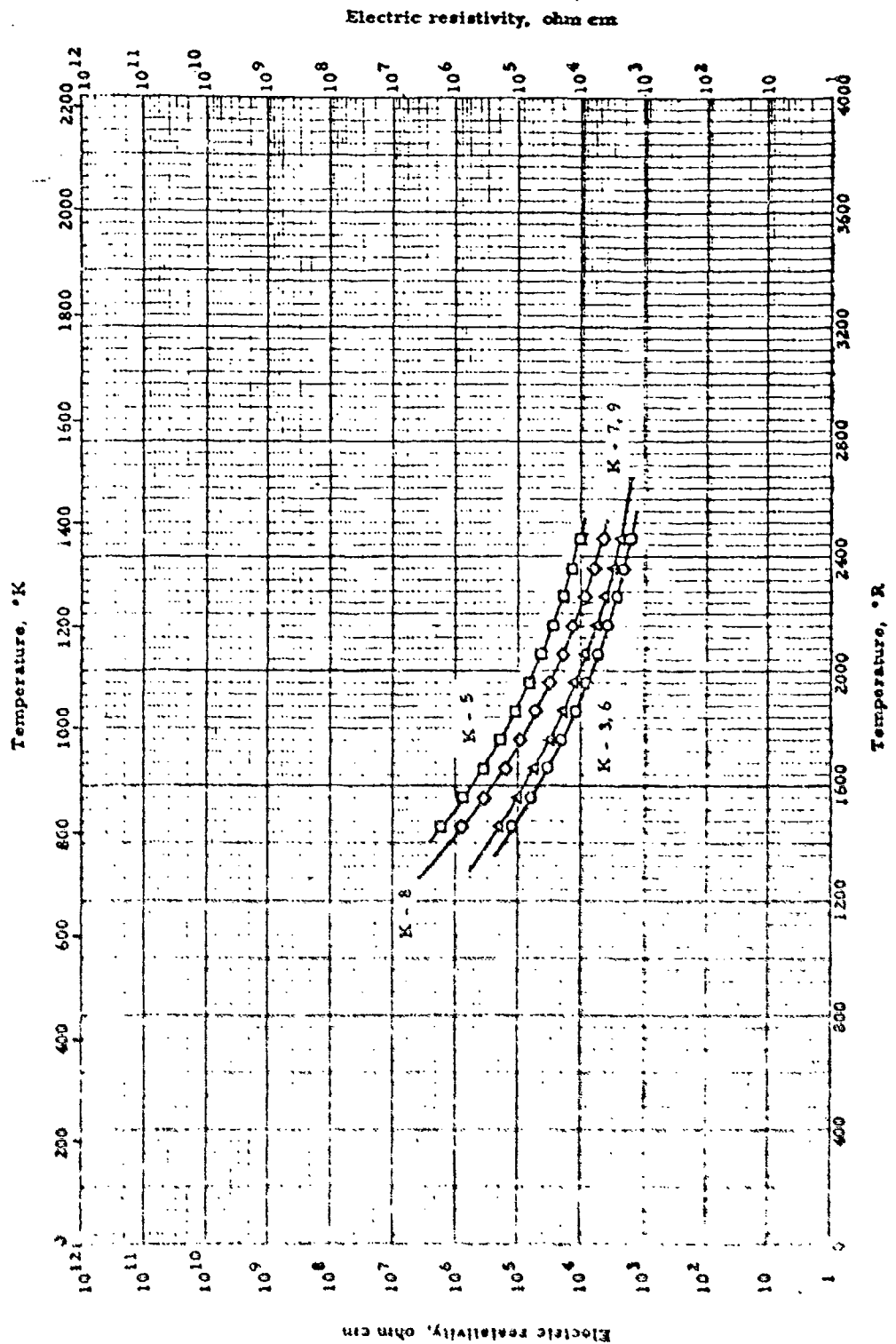
VII - E - 6

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LOW TENSION

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LOW TENSION

REFERENCE INFORMATION

S. N. Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Wiscaly, H. R.	57-98	1460-2460	Feldspar Porcelain: Dinnerware Conc 12-14. Nominal: 73-76% SiO ₂ ; 20-24% Al ₂ O ₃ ; 2-4% (K, Na) ₂ O; balance (Ca, Mg)O	AC impedance bridge; Chromel-Alumel thermocouple	Auth. reports range of values
Q	Bld.	57-98	1460-2460	Feldspar Porcelain: low tension electrical grade: nominal: 68-70% SiO ₂ ; 23-27% Al ₂ O ₃ ; 5-6% (K, Na) ₂ O; balance (Ca, Mg)O	Same as above	Auth. reports range of values
A	Bld.	57-98	1460-2460	Porcelain, Conc 14. Nominal: 76% SiO ₂ ; 21% Al ₂ O ₃ ; 3% (K, Na) ₂ O	Same as above	Fired at 2535°F



ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN

REFERENCE INFORMATION

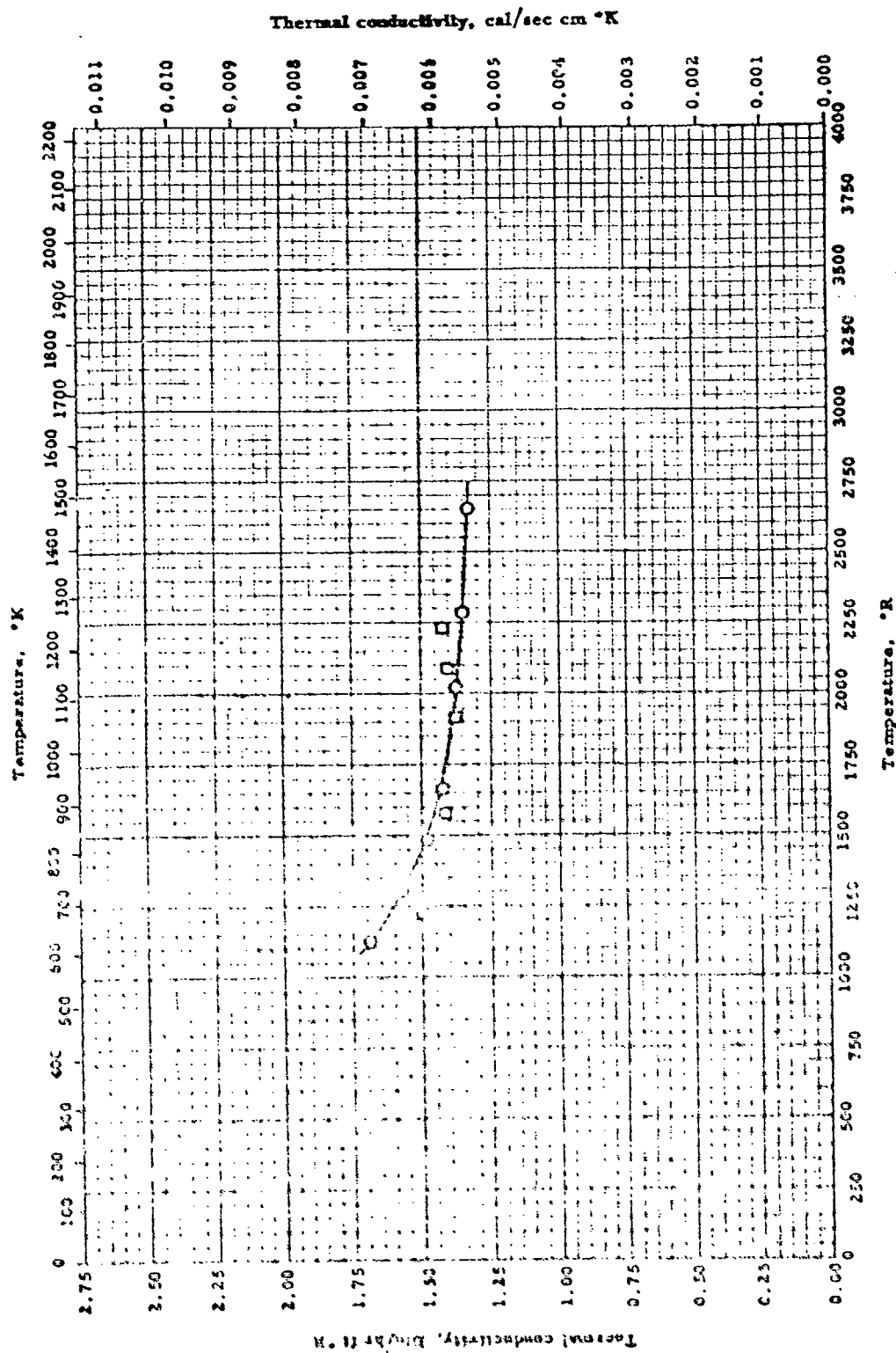
Investigator	Emf.	Range, °F.	Material Composition	Test Method	Remarks
C. Glaser, H. R.	57-90	1460-2460	K-3 body; nominal: 60% Al_2O_3 ; 20% SiO_2 ; 10% K_2O ; also: K-6 body; nominal: 45% SiO_2 ; 40% Al_2O_3 ; 15% K_2O	AC impedance bridge; Chromel-Alumel thermocouple	Fired at 2450°F. Fired at 2400°F, Same resistivity as K-3 body
C. Glaser.	57-90	1460-2460	K-5 body; nominal: 75% Al_2O_3 ; 20% SiO_2 ; 5% K_2O	Same as above	Fired at 2600°F
A. Glaser.	57-90	1460-2460	K-7 body; nominal: 68% SiO_2 ; 40% Al_2O_3 ; 12% K_2O ; also: K-9 body; nominal: 45% Al_2O_3 ; 45% SiO_2 ; 10% K_2O	Same as above	Fired at 2400°F Fired at 2400°F, Same resistivity as K-7 body
C. Glaser.	57-90	1460-2460	K-8 body; nominal: 53% Al_2O_3 ; 40% SiO_2 ; 7% K_2O	Same as above	Fired at 2450°F

59-323

WADC TR 58-476

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VII - 3 - 9



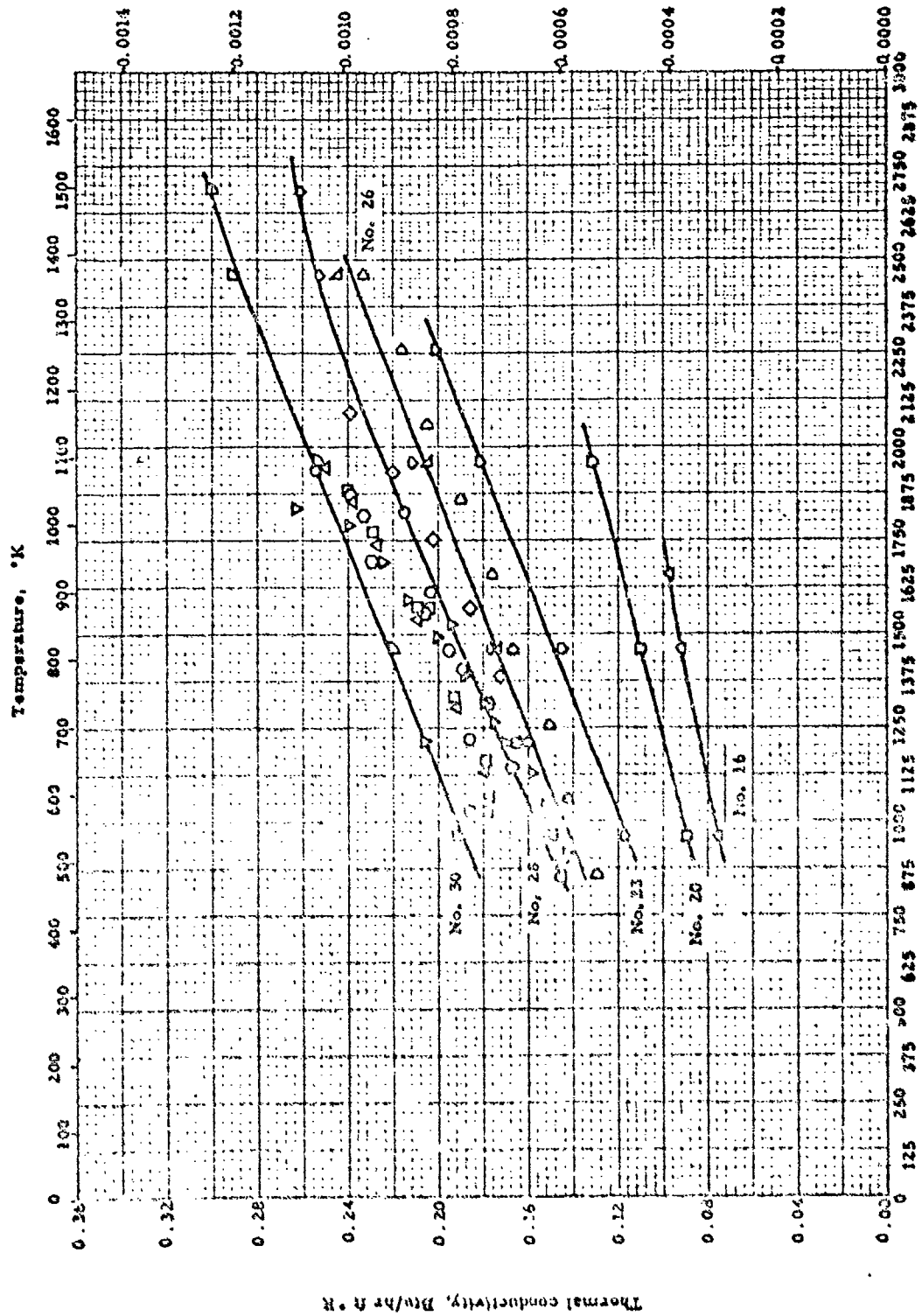
Thermal conductivity -- ALUMINA BRICK

1997

REFERENCE INFORMATION

Inventor	Pat. No.	Range, °F.	Material Composition	Test Method	Remarks
Clements, J. F. and Vose, J.	37-26	1122-2652	5.9% Al_2O_3 ; 10.08% SiO_2 ; 2.08% TiO_2 ; 0.86% Fe_2O_3 ; 0.35% K_2O ; 0.24% CaO ; 0.10% Na_2O ; 0.08% loss on ignition. Bulk $p = 178 \text{ lb}_m/ft^3$ (corrected, $p = 228.7$); apparent porosity = 22.1%	Not given (method of Brit. Ceramic Research Assoc.)	Auth. est. accuracy $\pm 5\%$
Wase, F., Wase, A. and Helm, J.	37-481	1220-2220	Maltese brick	Comparative: discs; heated guard cylinder	

Thermal conductivity, cal/sec cm °K



Temperature, °R

Thermal conductivity -- INSULATING FIREBRICK

THERMAL CONDUCTIVITY -- INSULATING FIREBRICK

REFERENCE INFORMATION

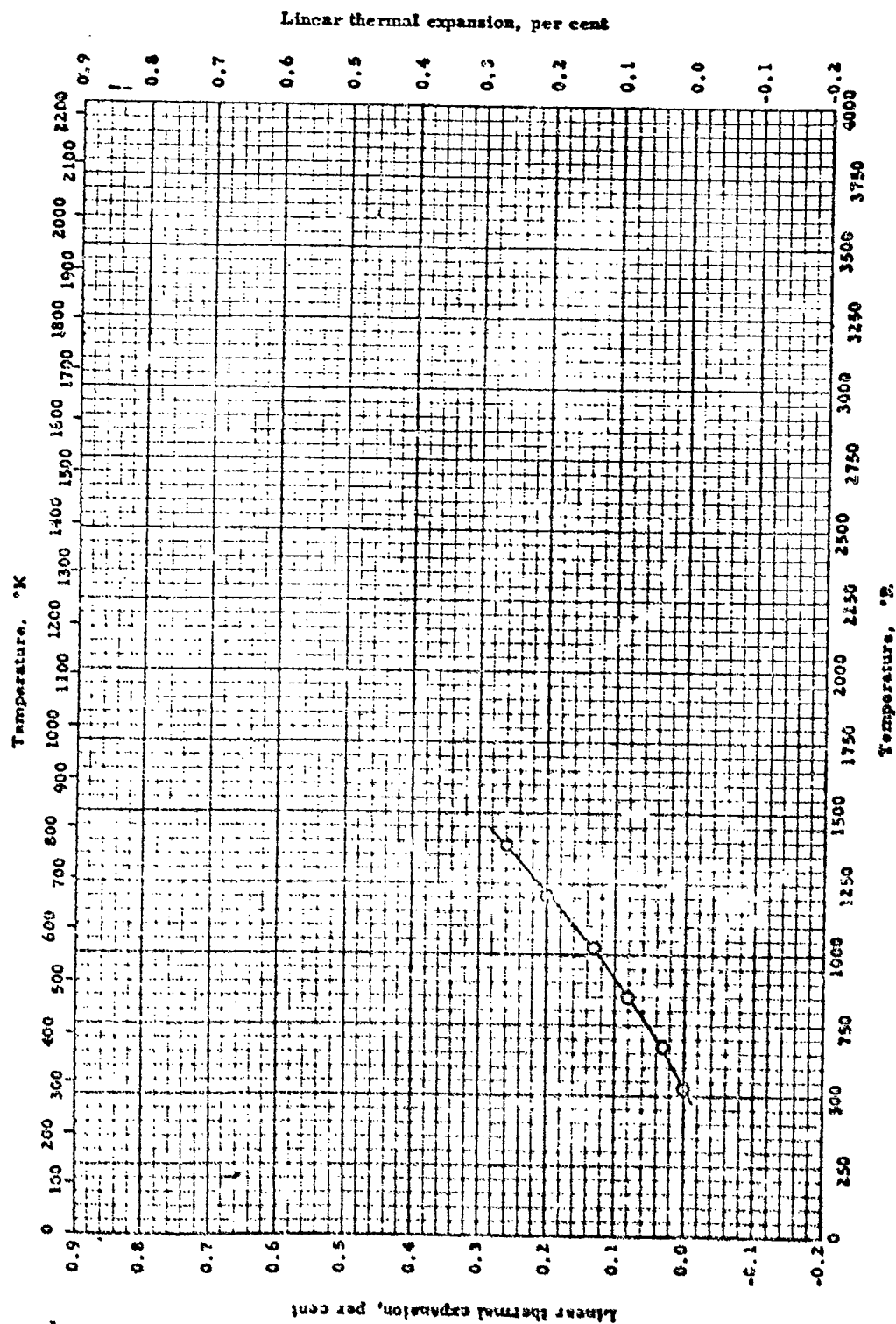
Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O Norton, F. H., Fellows, D. M. et al.	49-62	1028-1825	Insulating firebrick K-28	Cylindrical envelope, hemi-spherical end Temp by chromel-alumel thermocouple	Made by Babcock and Wilcox 2.5 lb per standard brick
O Norton, F. H., Fellows, D. M.	50-64	1031-1883	Insulating firebrick K-28	Prolate ellipsoid with heavy insulating cover	Made by Babcock and Wilcox, run no. 1
Δ Ibid.	50-64	1037-1543	Same as above	Same as above	Same as above, but run no. 2
Δ Ibid.	50-64	895-2394	Same as above	Same as above	Same as above, but run no. 3
▽ Norton, F. H., and Kingsley, W. D. et al.	51-76	513-1838	Insulating firebrick K-28	Ellipsoidal sample	Made by Babcock and Wilcox, run no. 2
O Ibid.	51-76	976-1873	Same as above	Same as above	Same as above, but run no. 3
O Norton, F. H.	51-77	352-1932	Insulating firebrick, K-18	Ellipsoidal envelope method	Auth. est. accuracy $\pm 20\%$
Δ Brady, J. C. and Matthews, S.	56-55	960-1660	Insulating firebrick, ASTM group no. 16	Single flat plate, circulating water calorimeter, ASTM methods C 182-47 and C 201-47	
O Ibid.	56-55	960-1960	Insulating firebrick, ASTM group no. 20	Same as above	
Δ Ibid.	56-55	960-2260	Insulating firebrick, ASTM group no. 23	Same as above	
L Ibid.	56-55	960-2460	Insulating firebrick, ASTM group no. 26	Same as above	
O Ibid.	56-55	960-2560	Insulating firebrick, ASTM group no. 28	Same as above	
D Ibid.	56-55	960-2560	Insulating firebrick, ASTM group no. 30	Same as above	
D Brady, J. C.	54-53	860-2460	Insulating firebrick ASTM group no. 36	Single flat plate, circulating water calorimeter, ASTM methods C 182-47 and C 201-47	Main purpose was to describe method and equipment.

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WADC TR 58-476

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VII - E - 9

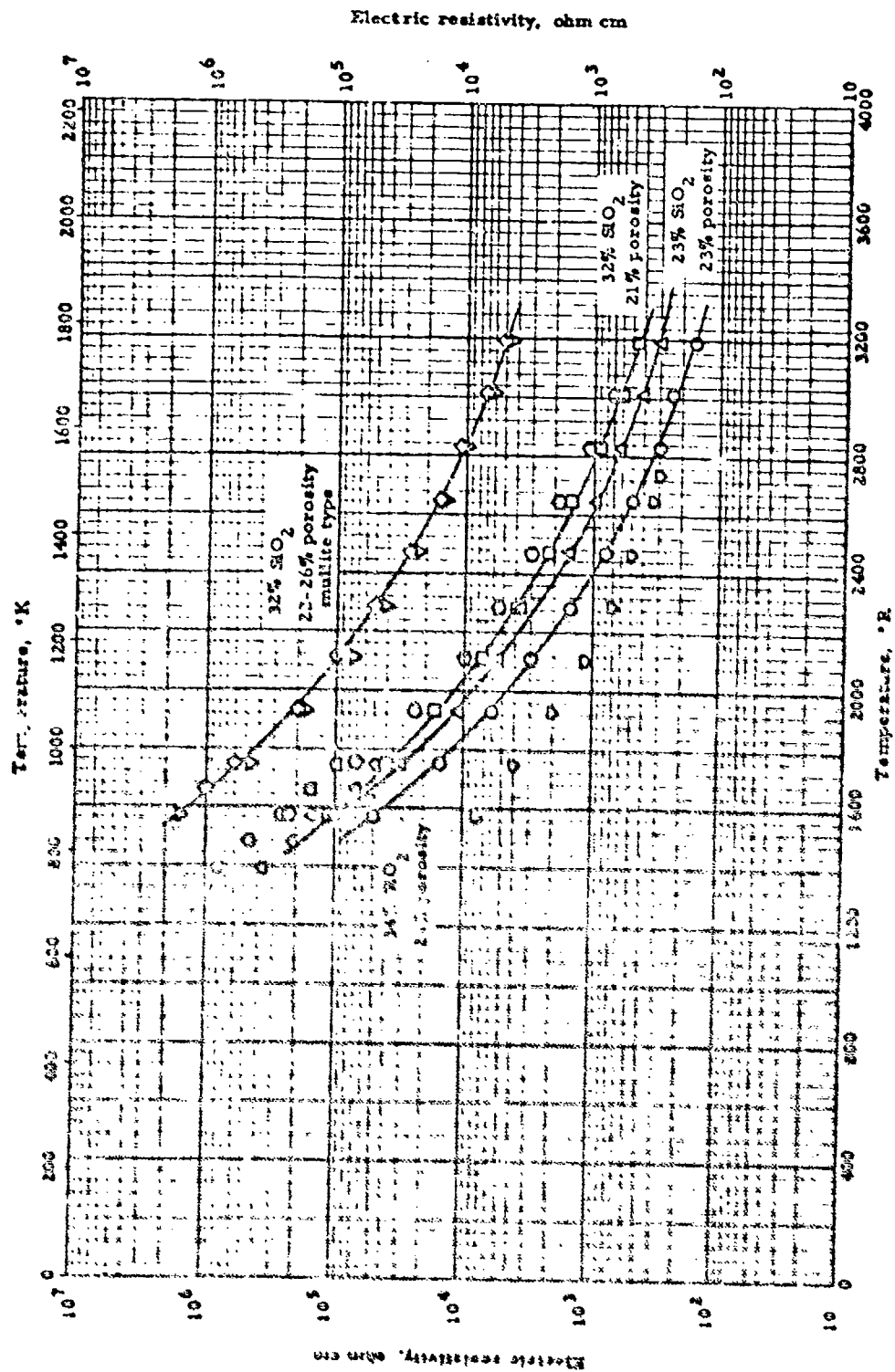


LINEAR THERMAL EXPANSION -- K-30 INSULATING BRICK

LINEAR THERMAL EXPANSION -- K-30 INSULATING BRICK

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Zimmerman, W. P., Pittsburgh, W. J., and Bennett, D. G.	53-42	528-1392	Not given	Interferometer	



ELECTRIC RESISTIVITY -- ALUMINA FIREBRICK
Commercial Brick

59-1065

WADC TR 58-476

III

6-3-74

ELECTRIC RESISTIVITY -- ALUMINA FIREBRICK
Commercial Brick

REFERENCE INFORMATION

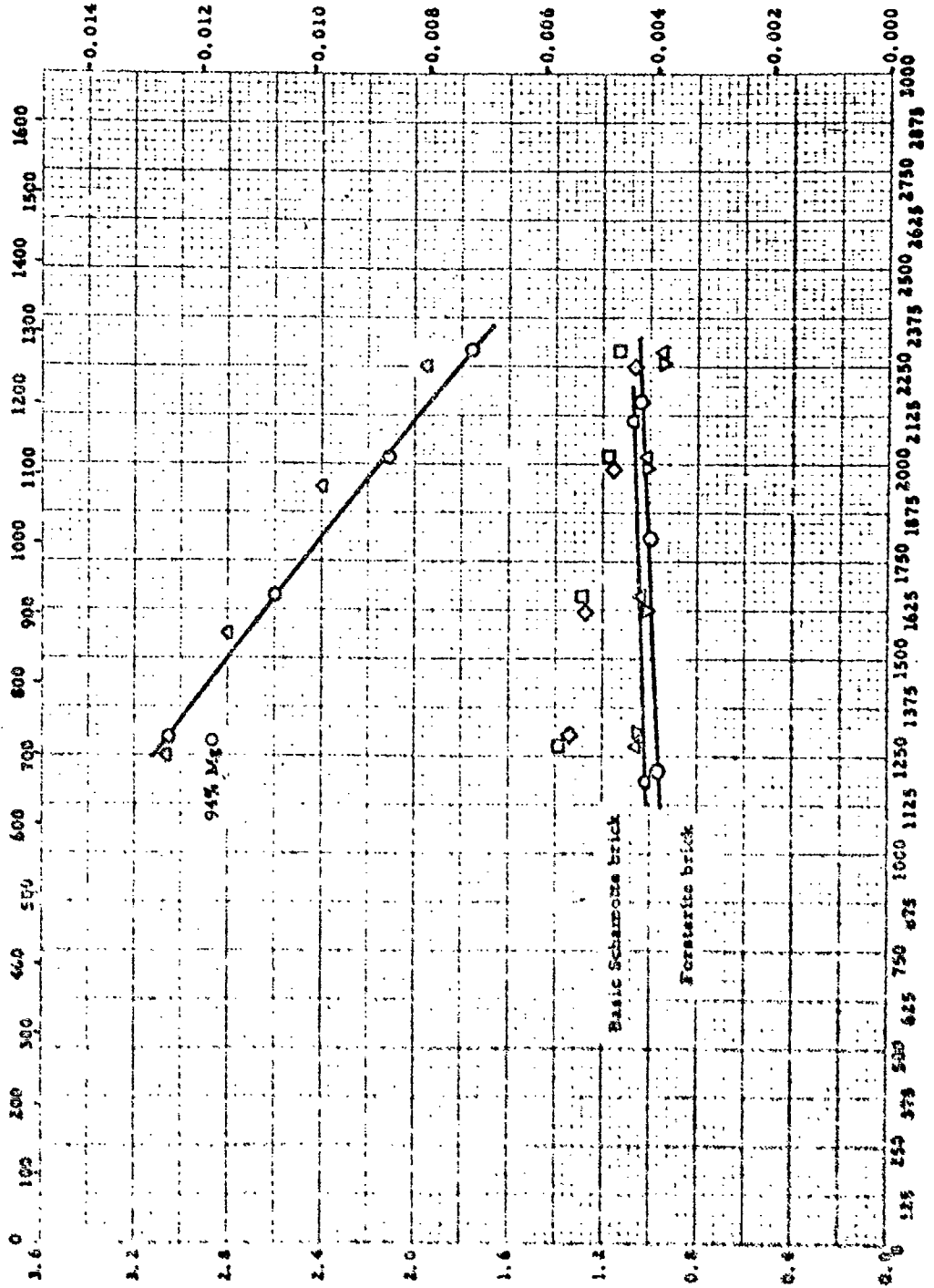
Ref.	Investigator	Range, °F.	Material Composition	Test Method	Remarks
53-94	Calichetti, V.E.J. and Henry, E. C.	1572-3192	34% SiO ₂ ; 60% Al ₂ O ₃ ; 24% porosity	Wheatstone bridge at 965 cycles	35-37 pyrometric cone equivalent
53-94	Ibid.	1572-3192	32% SiO ₂ ; 62% Al ₂ O ₃ ; 21% porosity	Same as above	36-37 pyrometric cone equivalent
53-94	Ibid.	1572-3192	23% SiO ₂ ; 69% Al ₂ O ₃ ; 73% porosity	Same as above	37-38 pyrometric cone equivalent
53-94	Ibid.	1572-3192	32% SiO ₂ ; 64% Al ₂ O ₃ ; 25% porosity; mullite type	Same as above	38 + pyrometric cone equivalent
53-94	Ibid.	1572-3192	33% SiO ₂ ; 64% Al ₂ O ₃ ; 22% porosity; mullite type	Same as above	37-8 pyrometric cone equivalent
53-94	Ibid.	1572-3192	Not given. Fused; mullite type	Same as above	37-8 pyrometric cone equivalent
53-94	Ibid.	1572-2742	20% Al ₂ O ₃ ; 20% chromite; 2.9% porosity	Same as above	37-8 pyrometric cone equivalent
55-1a2	Budakov, P.P. and Tretyyatski, S. G.	1392-1752	95% white corundum; 5% clay. White corundum: 95.55% Al ₂ O ₃ ; 2.50% SiO ₂ ; 0.30% CaO; 0.25% Fe ₂ O ₃ ; 0.16% MgO; 0.55% residue. Clay: 53.17% SiO ₂ ; 31.6% Al ₂ O ₃ ; 0.90% Fe ₂ O ₃ ; 0.54% CaO; 0.30% MgO; 12.95% residue.	AC bridge at 50 cycles/sec.	Fired 2 hr. at 1400°C. Plotted data avg. of 3 samples within ± 10%
55-1a2	Ibid.	1392-1752	50% white corundum; 50% clay Raw materials: same as above	Same as above	Same as above. Auth. also gives data for 10, 20, 30, and 40% clay which lie between the Q and Q

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935-09

Thermal conductivity, Btu/hr ft °K

Temperature, °K



Thermal conductivity, cal/sec cm °K

Temperature, °R

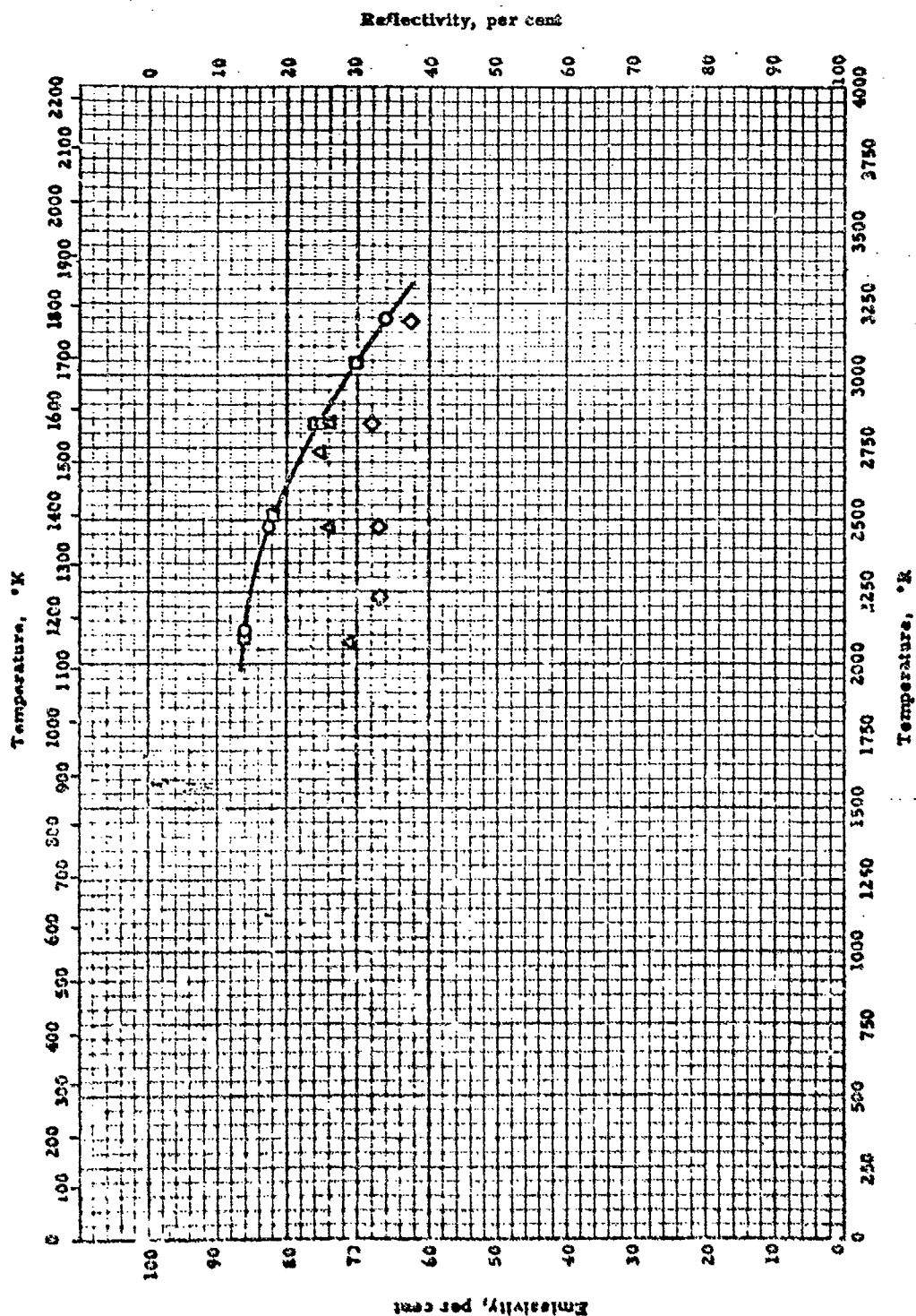
THERMAL CONDUCTIVITY -- BASIC REFRACTORY

10 - 2 - 10

THERMAL CONDUCTIVITY -- BASIC REFRACTORY

REFERENCE INFORMATION

Investigator	Ref. Range, °R	Material Composition	Test Method	Remarks
Galachova, A. F. and Gorchakov, V. V.	53-142 1302-2292	53.82% MgO; 2.08% SiO ₂ ; 1.62% Fe ₂ O ₃ ; 1.24% CaO; 0.81% Al ₂ O ₃ ; 0.05% TiO ₂ ; Porosity = 25% p = 175 lb _m /ft ³	Radial heat flow in bar with calorimeter	Auth. est. accuracy ± 3.0%
RD4.	55-143 1302-2292	64.85% MgO; 12.23% Cr ₂ O ₃ ; 8.57% Al ₂ O ₃ ; 5.86% Fe ₂ O ₃ ; 4.28% SiO ₂ ; 1.67% FeO; 1.44% CaO. Porosity = 19.1%, p = 190 lb _m /ft ³	Same as above	Same as above
RD4.	55-143 1302-2292	49.45% MgO; 20.48% Cr ₂ O ₃ ; 12.59% Al ₂ O ₃ ; 9.15% Fe ₂ O ₃ ; 5.24% SiO ₂ ; 1.90% FeO; 1.26% CaO. Porosity = 22.8%, p = 184 lb _m /ft ³	Same as above	Same as above
RD4.	55-143 1302-2292	42.87% MgO; 22.34% Cr ₂ O ₃ ; 13.04% Fe ₂ O ₃ ; 11.45% Al ₂ O ₃ ; 5.42% SiO ₂ ; 2.83% FeO; 1.76% CaO. Porosity = 25.6%, p = 184 lb _m /ft ³	Same as above	Same as above
RD4.	55-143 1302-2292	42.31% MgO; 24.35% Cr ₂ O ₃ ; 12.34% Al ₂ O ₃ ; 11.94% Fe ₂ O ₃ ; 6.14% SiO ₂ ; 1.71% FeO; 1.55% CaO. Porosity = 23.5%, p = 189 lb _m /ft ³	Same as above	Same as above
Krasov, F., Hutina, A. and Kala, J.	57-181 1212-2157	Forsterite brick	Comparative, diasc. simple guard heater reduced but did not eliminate heat leakage. Temp. by thermocouples	
RD4.	57-181 1212-2121	Basic Schramette brick	Same as above	
RD4.	57-181 1248-2247	Magnesite brick "M"	Same as above	

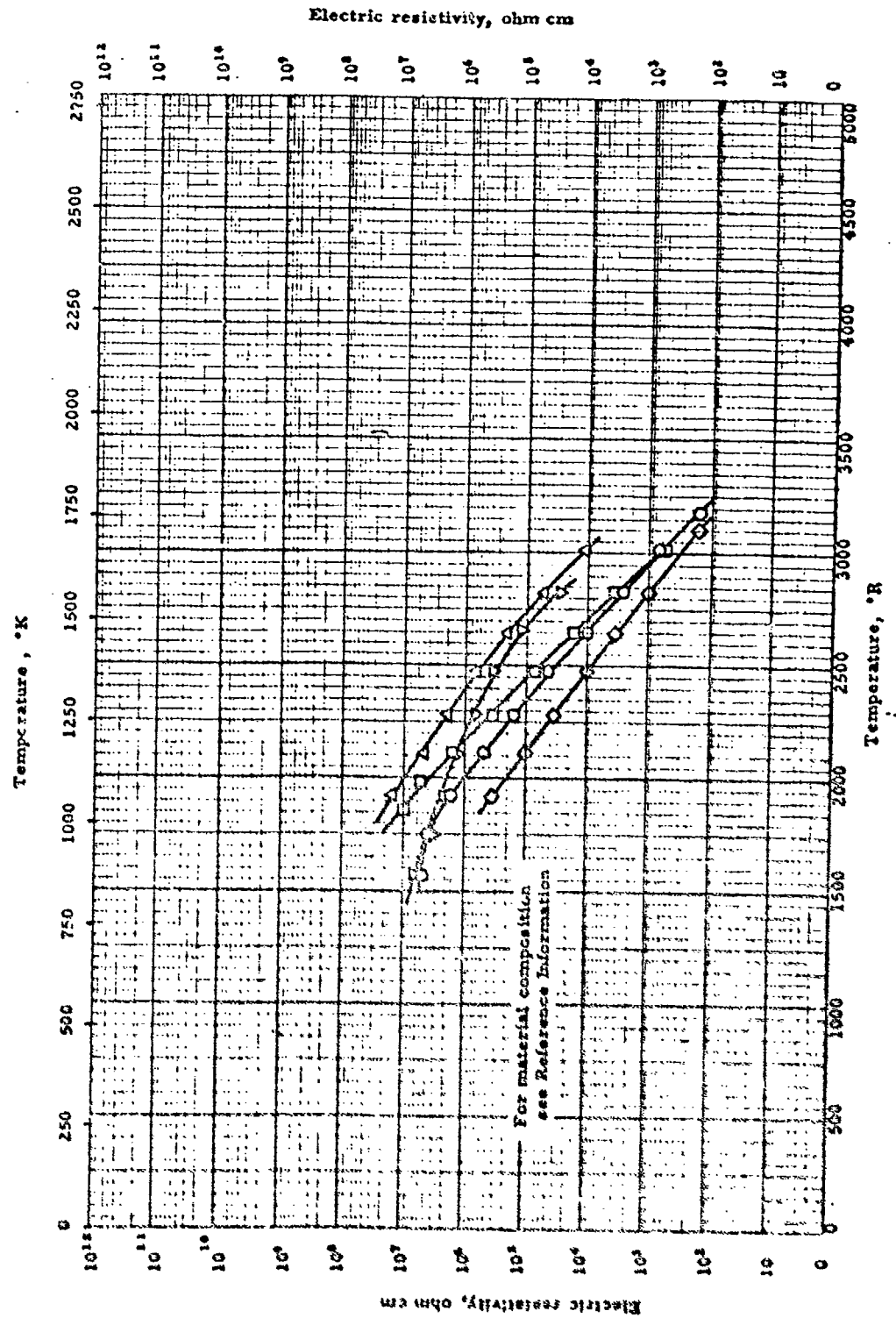


EMISSIVITY -- CHROME MAGNESITE

SENSITIVITY -- CHROME MAGNESITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Partison, J. R.	55-86	2112-3192	Chrome magnesite basic firebrick	Total normal emissivity: Hilger thermopile. Temp. by optical pyrometer focused on black body hole	Red block
□	E.H.	55-86	2694-3048	Same as above	Same as above	Used brick
△	E.H.	55-86	2076-2742	Same as above	Same as above	1st sample contaminated with iron oxide
◇	E.H.	55-86	2238-3192	Same as above	Same as above	2nd sample contaminated with iron oxide

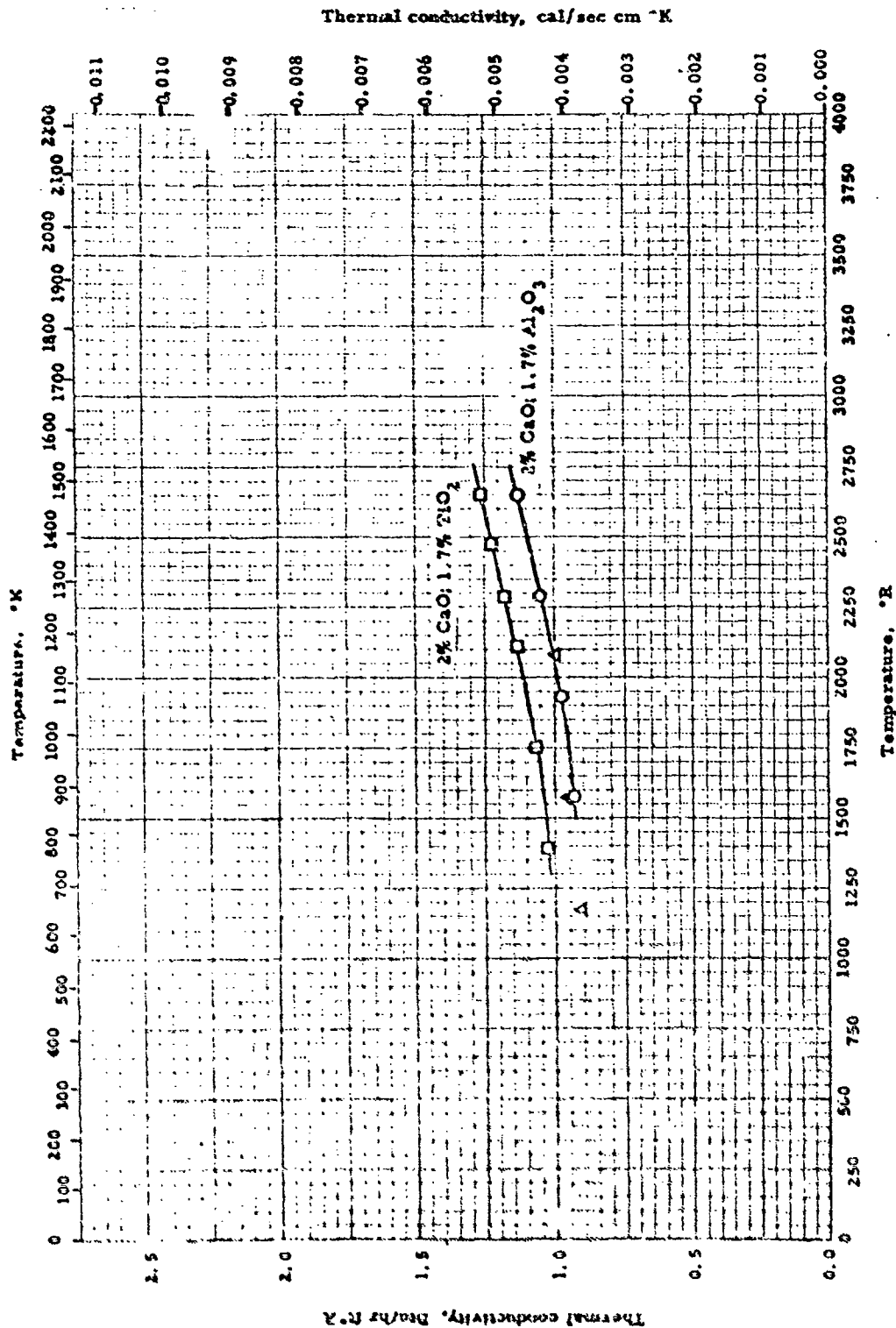


ELECTRIC RESISTIVITY -- BASIC BRICK

ELECTRIC RESISTIVITY -- BASIC BRICK

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
1	Chubbett, V. E. J. and Henry, E. G.	53-94	1572-3192	Basic brick (Forsterite) commercial material; composition not given; apparent porosity 21%	Wheatstone bridge at 965 cycles	Auth. est. error ± 10% at 10 ⁴ ohm-cm ± 4% at 50,000 ohm-cm ± 0.3% at 100 ohm-cm
2	Did.	53-94	1160-3020	26% MgO; porosity = 18%	Same as above	Same as above
3	Did.	53-94	1930-3020	90-95% MgO; porosity = 17%	Same as above	Same as above
4	Did.	53-94	1930-3100	Magnesite-chrome; porosity = 19%	Same as above	Same as above
5	Did.	53-94	1570-2830	Chrome-magnesite; porosity = 16%	Same as above	Same as above



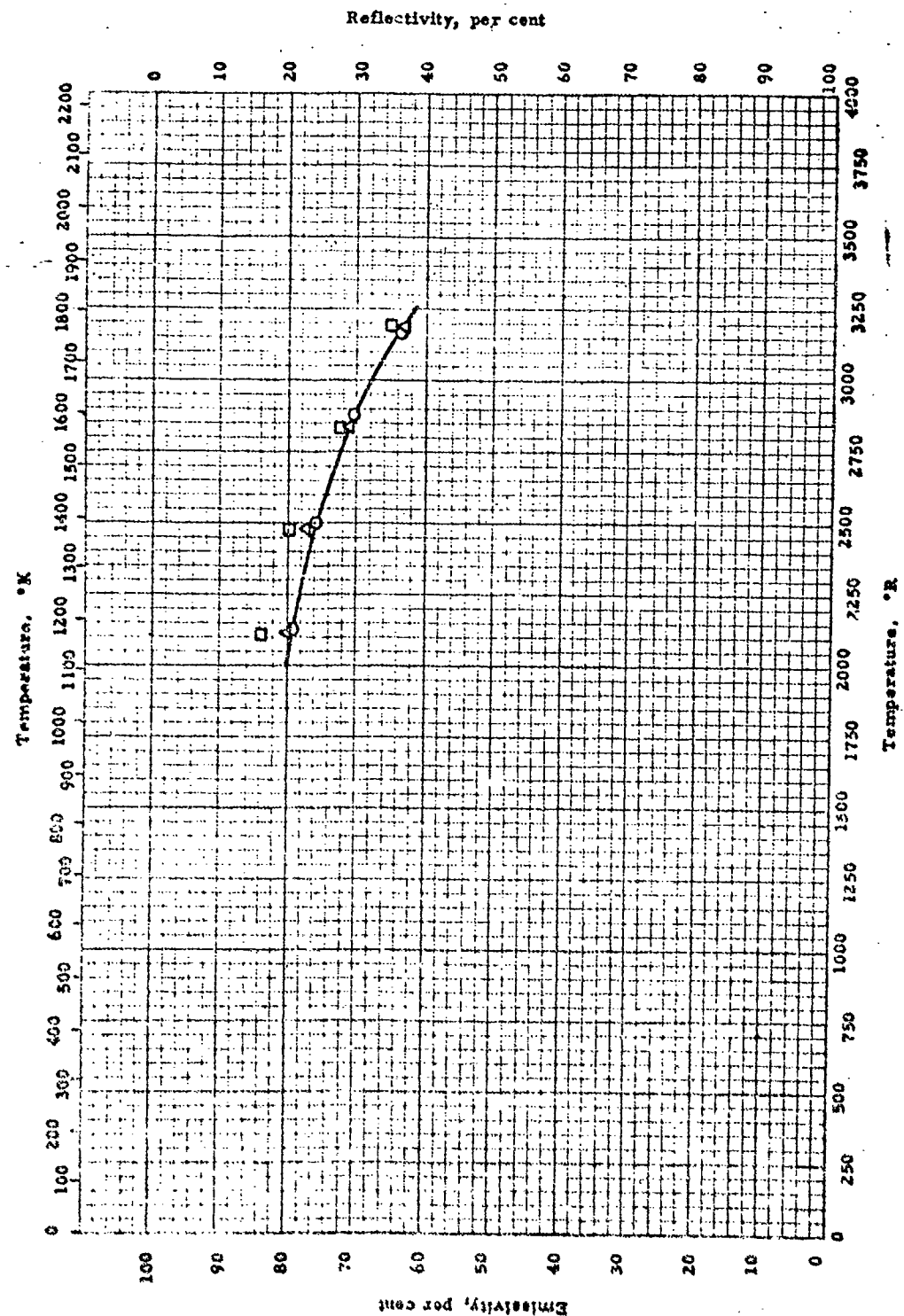
Thermal conductivity -- SILICA BRICK

THERMAL CONDUCTIVITY -- SILICA BRICK

REFERENCE INFORMATION

Spec. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Clements, J. F. and Vyse, J.	57-26	1572-2652	95.33% SiO ₂ ; 2.07% CaO; 1.71% Al ₂ O ₃ ; 0.53% Fe ₂ O ₃ ; 0.25% Na ₂ O; 0.13% K ₂ O; 0.12% TiO ₂ ; 0.12% loss on ignition. Bulk $\rho = 137 \text{ lb}_m/\text{ft}^3$ (cf. theor. $\rho = 146$) apparent porosity = 26.4%	Not described; used apparatus of Brit. Ceramic Research Assn.	Auth. est. accuracy $\pm 5\%$
Q	Ibid.	57-26	1392-2652	94.20% SiO ₂ ; 2.01% CaO; 1.72% TiO ₂ ; 0.76% Fe ₂ O ₃ ; 0.29% Al ₂ O ₃ ; 0.22% MnO; trace of MgO; no A ₂ C, Na ₂ O or loss on ignition. Bulk $\rho = 119 \text{ lb}_m/\text{ft}^3$ (cf. theor. $\rho = 146$) apparent porosity = 18.7%	Same as above	Made from South African silcrete rock. Auth. est. accuracy $\pm 5\%$
A	Kasse, F., Helms, A. and Hein, J.	57-191	1170-2090	Coke oven silica brick	Comparative, disks with heated guard cylinder	

WADC TR 58-476 1121

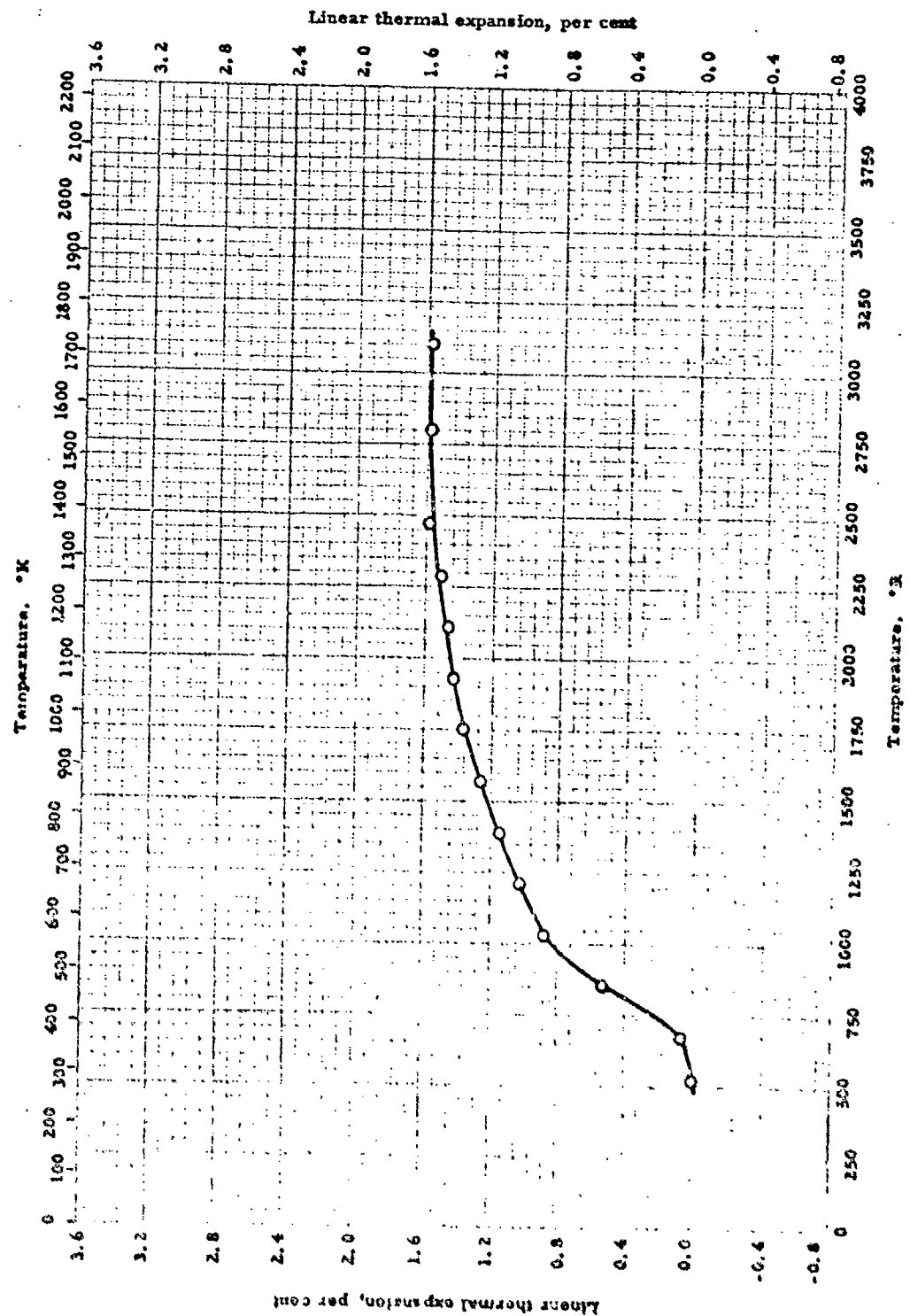


EMISSIVITY -- SILICA BRICK

EMISSIVITY -- SILICA BRICK

REFERENCE INFORMATION

Sam No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
0	Pattison, J. R.	55-85	2112-3192	Silica firebrick	Total normal emissivity: Hilger thermopile. Temp. by optical pyro- meter focused on black body hole	
□	Dtd.	55-86	2112-3192	Silicrete quality silica brick	Same as above	
△	Dtd.	55-86	2112-3192	Standard roof quality silica brick	Same as above	



LINEAR THERMAL EXPANSION -- SILICA BRICK

LINEAR THERMAL EXPANSION -- SILICA BRICK

REFERENCE INFORMATION

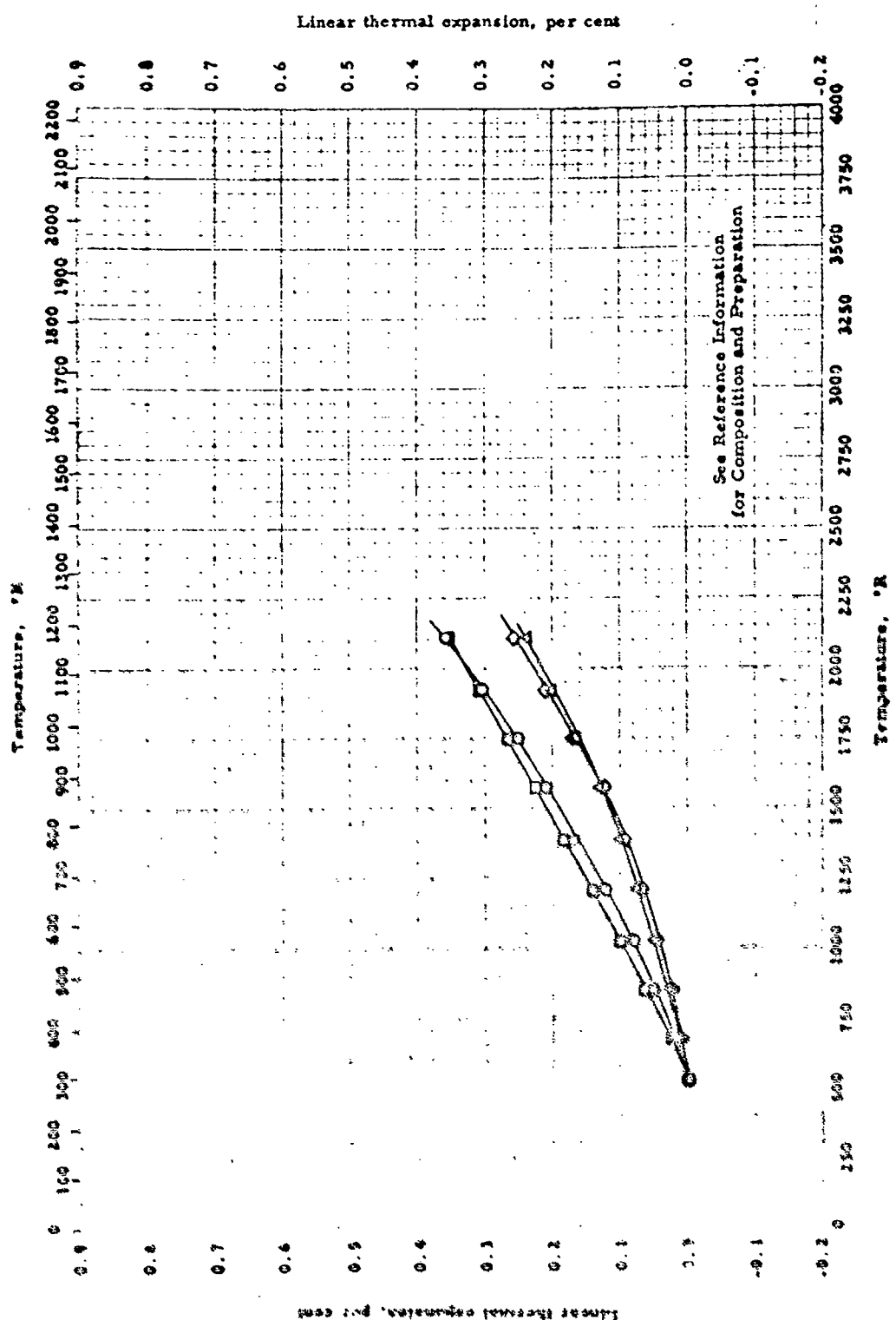
Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O Pawlowski, S.	27-183	672-3103	Silica Refractory. 97.43 - 98.36% SiO ₂ ; 1.2 - 1.6% R ₂ O ₃ ; 0.25 - 0.49% CaO. $\rho = 141 \text{ lb}_{\text{m}}/\text{ft}^3$	Not given	Made from 70-79% Cristobolite; 12-18% trysdemite; 9-12% quartz; Material III-H. Mixed 18 min., hydraulically pressed 5 times at 800 kg/cm ² , dried, fired

59-508

WADC TR 54-476

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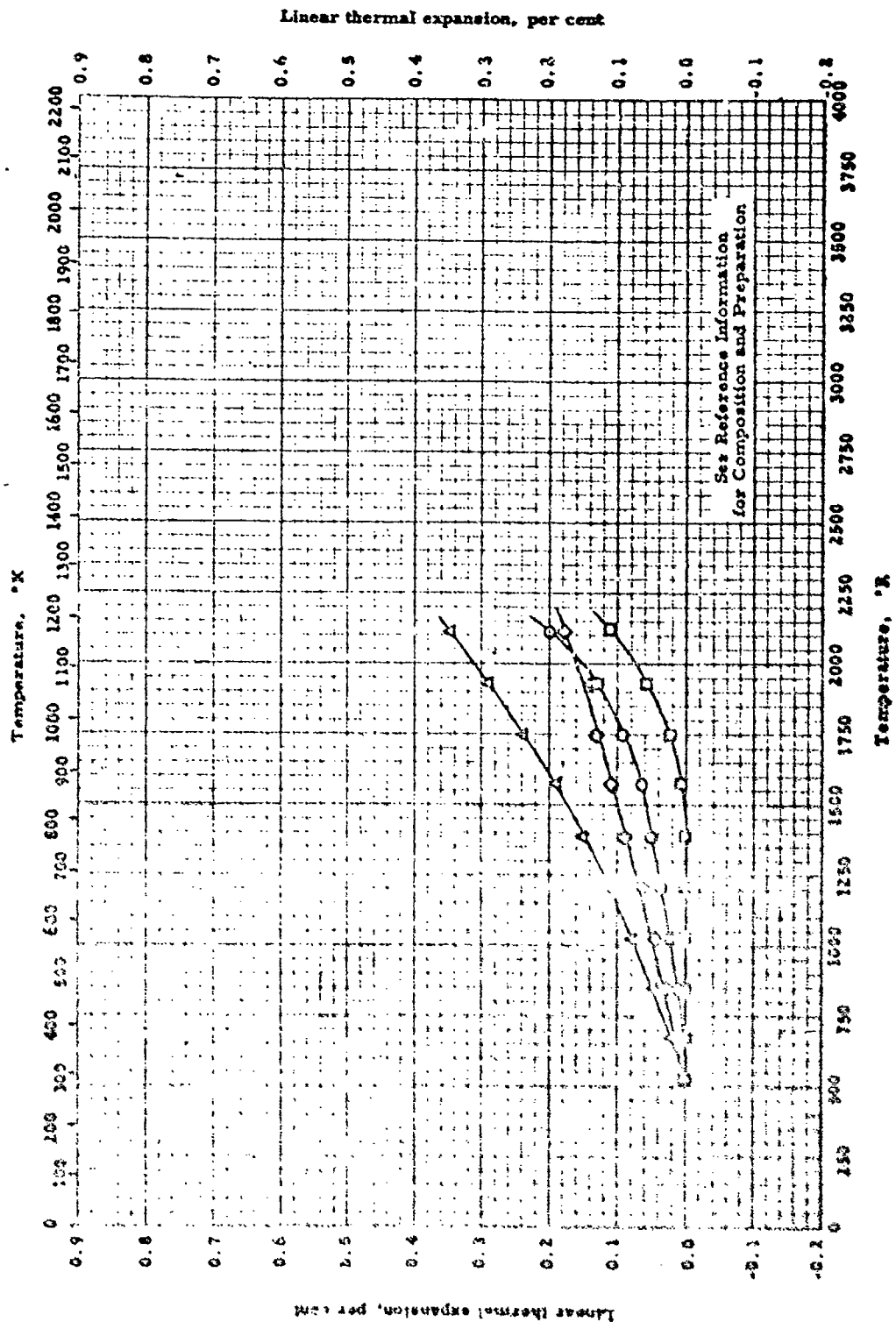


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
 (58 - 68 vol % Al_2O_3 , TiO_2 ; 21 - 39 vol % $\alpha - Al_2O_3$ inclusions; 0 - 10 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS EXDED ALUMINUM TITANATE
(58 - 68 vol % Al_2O_3 · TiO_2 ; 21 - 39 vol % α - Al_2O_3 Inclusions; 0 - 10 vol % Mullite)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W.J. and Harman, C.G.	50-12	528-2112	67.5 vol % Al_2O_3 · TiO_2 crystals; 21.6 vol % α - Al_2O_3 inclusions; 10.0 vol % mullite crystals; 1.0 vol % isotropic glass, apparent porosity 7.80%	Not given	Equimolar mix of fused Al_2O_3 (50) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr. to 650°C, fired in 26 hr. to 1820°C, held 1 hr. furnace cooled, powdered, mixed with more fused Al_2O_3 , fired to 1650°C
□	Ibid.	50-12	528-2112	61.0 vol % Al_2O_3 · TiO_2 crystals; 38.7 vol % α - Al_2O_3 inclusions; 0.3 vol % mineral impurities, apparent porosity 22.6%	Same as above	Ignited γ - Al_2O_3 (1 μ) treated as above
△	Ibid.	50-12	528-2112	60.0 vol % Al_2O_3 · TiO_2 crystals; 33.8 vol % α - Al_2O_3 inclusions; 3.2 vol % mullite; 1.0 vol % isotropic glass, apparent porosity 3.53%	Same as above	Same as above
◇	Ibid.	50-12	528-2112	58.1 vol % Al_2O_3 · TiO_2 crystals; 37.9 vol % α - Al_2O_3 inclusions; 3.3 vol % mullite; 0.5 vol % isotropic glass, apparent porosity 6.06%	Same as above	Same as above

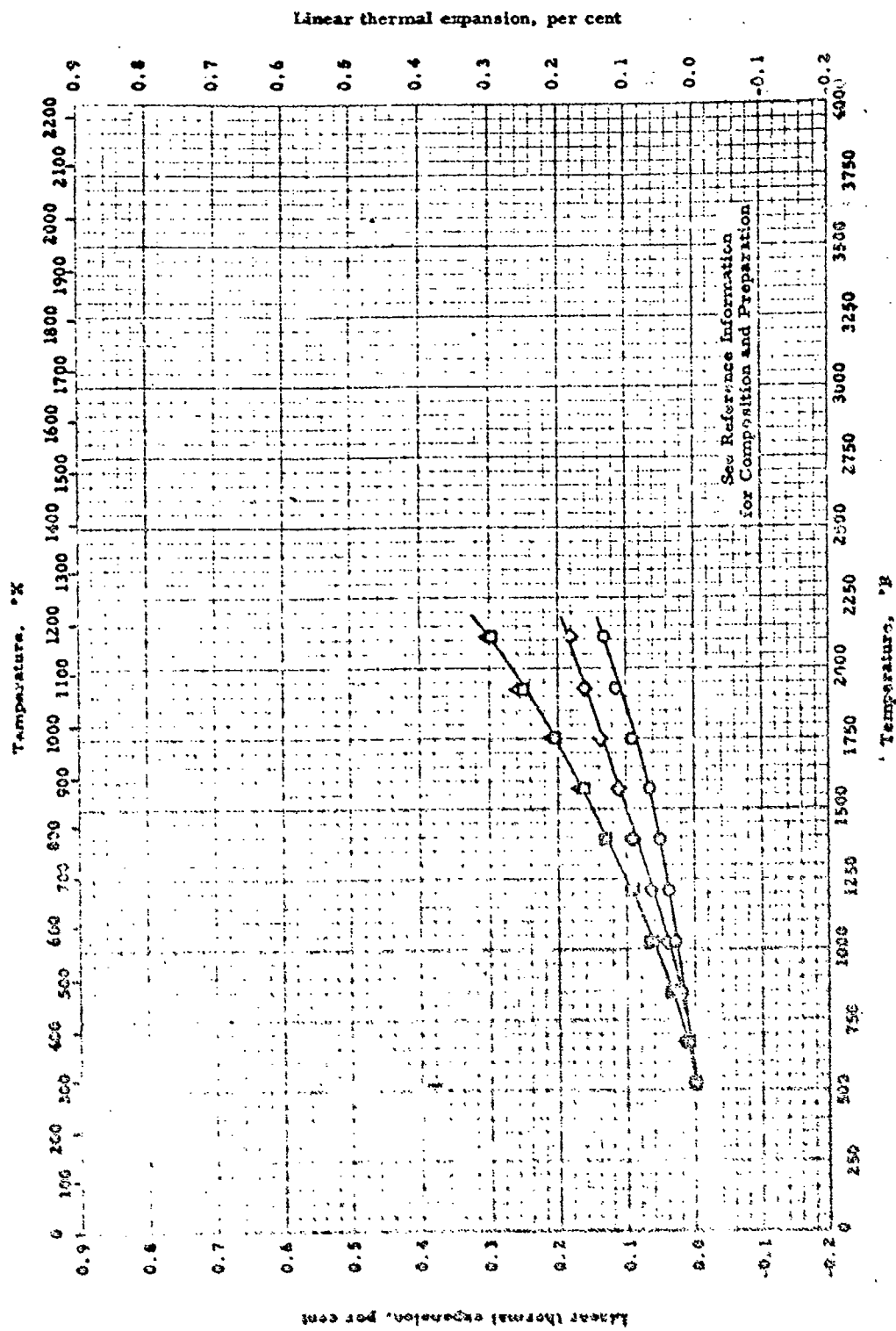


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
 (74 - 76 vol % Al_2O_3 , TiO_2 : 12 - 20 vol % SiO_2 Inclusions: 6 - 11 vol % Mullite)

LINEAR THERMAL EXPANSION -- CERAMIC BONDED ALUMINUM TITANATE
(74 - 78 vol % Al_2O_3 · TiO_2 ; 12 - 20 vol % α - Al_2O_3 Inclusions; 6 - 11 vol % Mullite)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
Q	Koch, W. J. and Harman, C. G.	50-12	528-2112	78 vol % Al_2O_3 · TiO_2 crystals; 11 vol % mullite crystals; 11 vol % isotropic glass, apparent porosity 7.08%	Not given	Equimolar mix of fused Al_2O_3 (64) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr to 650 C, fired in 26 hr to 1823 C, held 1 hr, furnace cooled, powder- ed, mixed with more fused Al_2O_3 , fired to 1650 C
Q	Did.	50-12	528-2112	77 vol % Al_2O_3 · TiO_2 crystals; 15 vol % iso- tropic glass; 8.0 vol % mullite crystals, ap- parent porosity 6.5%	Same as above	Same as above
A	Did.	50-12	528-2112	75.2 vol % Al_2O_3 · TiO_2 crystals; 12.8 vol % α - Al_2O_3 inclusions; 17 vol % mullite crystals; 1.0 vol % isotropic glass, apparent porosity 6.12%	Same as above	Same as above
Q	Did.	50-12	528-2112	74.0 vol % Al_2O_3 · TiO_2 crystals; 19.1 vol % α - Al_2O_3 inclusions; 6.4 vol % mullite crystals; 0.5 vol % isotropic glass, apparent porosity 5.81%	Same as above	Ignited 7% Al_2O_3 (14) treated as above

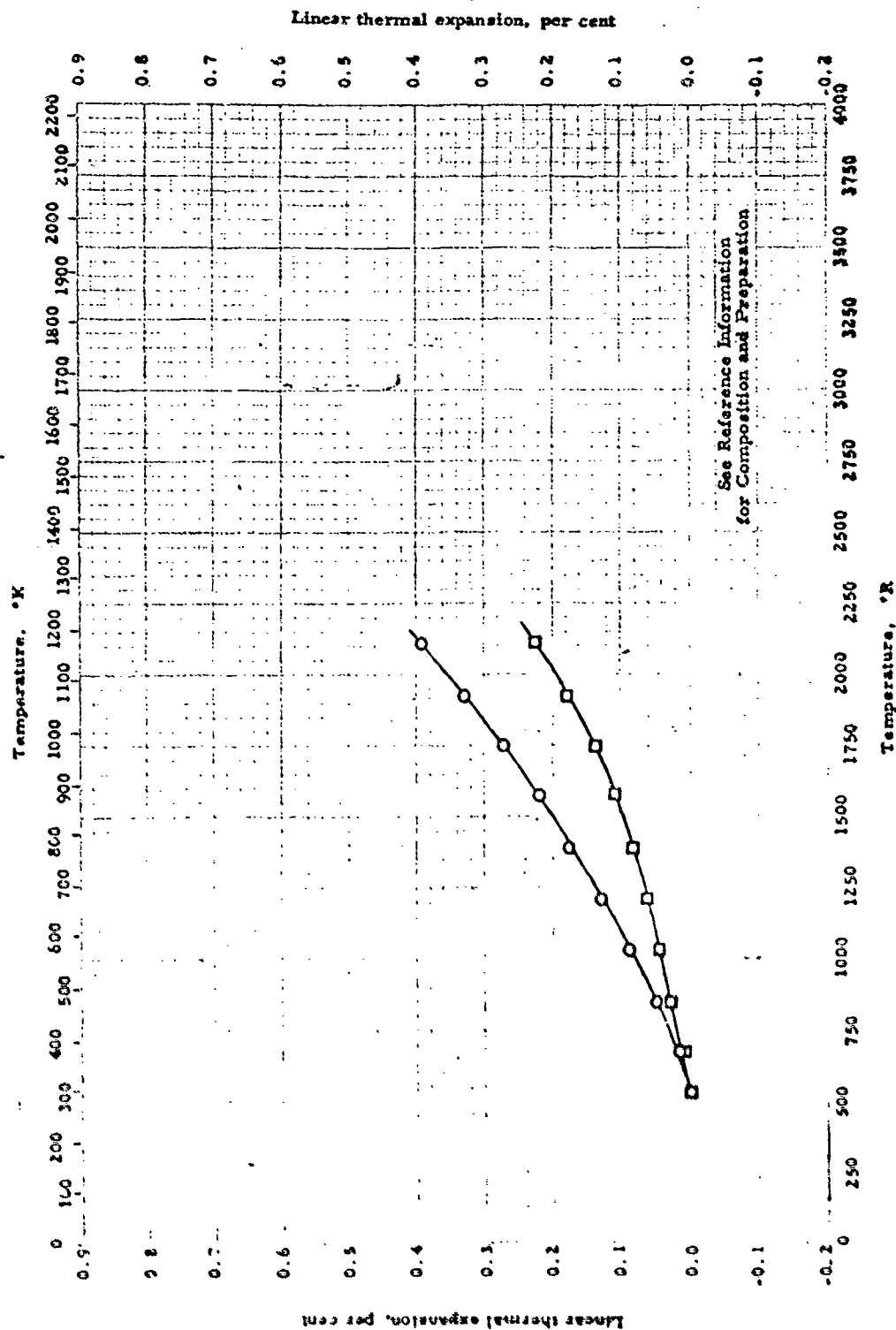


LINEAR THERMAL EXPANSION - VITREOUS BONDED ALUMINUM TITANATE
(89 - 87 vol % Al_2O_3 - TiO_2 ; 0 - 10 vol % Al_2O_3 Inclusions; 9 - 16 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(86 - 87 vol % Al_2O_3 - TiO_2 ; 0 - 10 vol % α - Al_2O_3 inclusions; 9 - 16 vol % Mullite)

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Tracy, W. J. and Hartman, C. C.	59-12	528-2112	87.0 vol % Al_2O_3 - TiO_2 crystals; 11 vol % mullite crystals; 1.0 vol % α - Al_2O_3 inclusions; 1.0 vol % isotropic glass, apparent porosity 6.26%	Not given	Equimolar mix of ignited γ - Al_2O_3 (1 μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr to 850°C, fired in 26 hr to 1620°C, held 1 hr, furnace cooled, powdered, mixed with more ignited γ - Al_2O_3 , fired to 1650°C
Tracy,	59-12	528-2112	83.9 vol % Al_2O_3 - TiO_2 crystals; 9.2 vol % mullite crystals; 4.9 vol % α - Al_2O_3 inclu- sions; 2.0 vol % isotropic glass, apparent porosity 5.57%	Same as above	Fused Al_2O_3 (6 μ) treated as above
Tracy,	59-12	528-2112	81 vol % Al_2O_3 - TiO_2 crystals; 16 vol % mullite crystals; 1 vol % isotropic glass, apparent porosity 7.08%	Same as above	Same as above
Tracy,	59-12	528-2112	80.6 vol % Al_2O_3 - TiO_2 crystals; 10.0 vol % mullite crystals; 2.4 vol % α - Al_2O_3 inclu- sions; 1.0 vol % isotropic glass, apparent porosity 5.67%	Same as above	Ignited γ - Al_2O_3 treated as above



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(72 - 76 vol % Al_2O_3 · TiO_2 ; 23 - 27 vol % α - Al_2O_3 Inclusions)

59-582

WADC TR 58-476

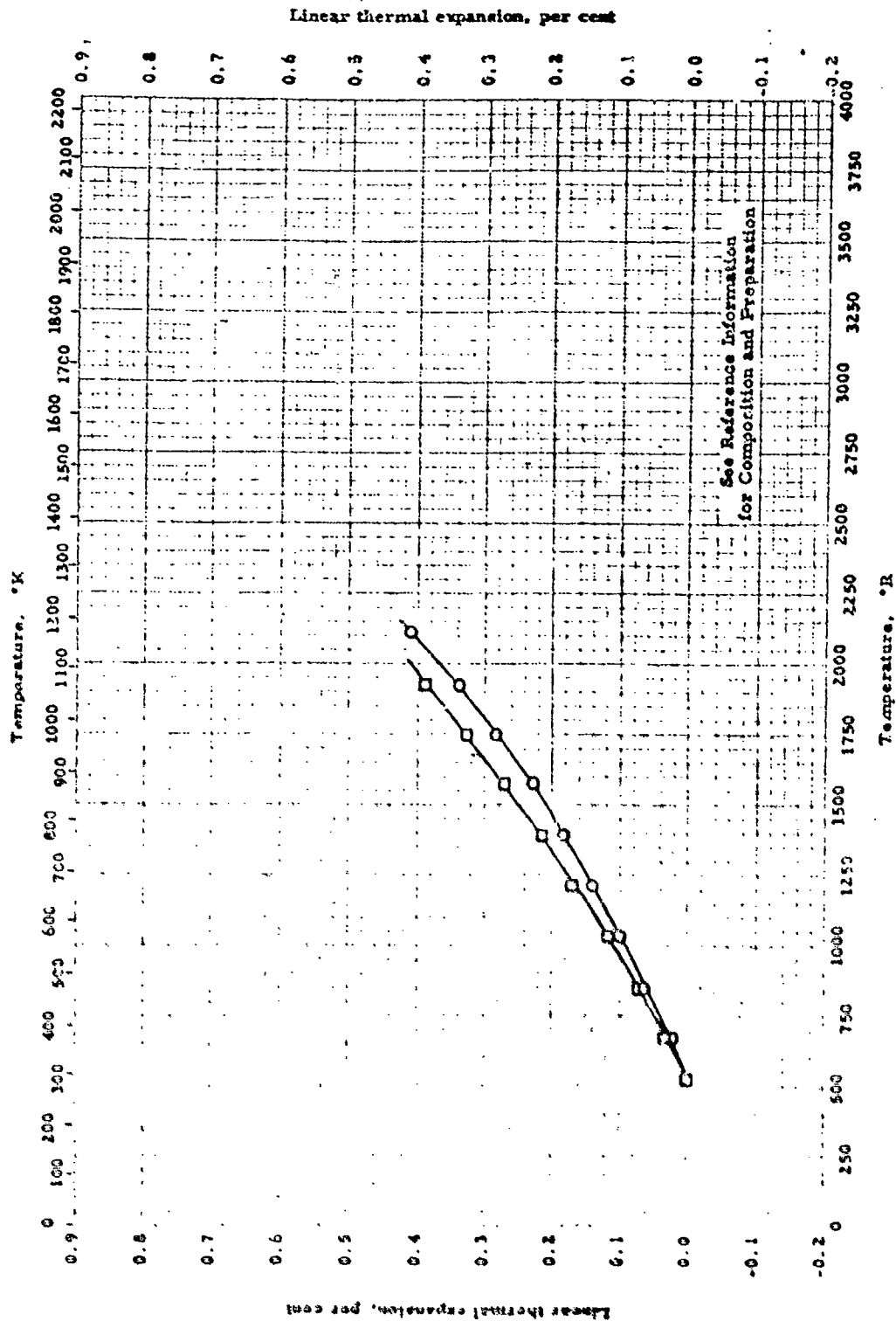
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VII - K

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(72 - 76 vol % Al_2O_3 , CaO , TiO_2 ; 23 - 27 vol % α - Al_2O_3 Inclusions)

REFERENCE INFORMATION

Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O Koch, W. J. and Harrison, C. C.	50-12	528-2112	75.3 vol % Al_2O_3 - TiO_2 crystals; 23.7% vol % α - Al_2O_3 inclusions; 1 vol % mineral impurities, apparent porosity 16.0%	Not given	Fused Al_2O_3 (6μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr. to 630°C, fired in 26 hr. to 1820°C, held 1 hr., furnace cooled
□ Indd.	50-12	528-2112	72.1% vol % Al_2O_3 - TiO_2 crystals; 26.9 vol % α - Al_2O_3 inclusions; 1 vol % mineral impurities, apparent porosity 10.5%	Same as above	Same as above



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(80 - 84 vol % Al_2O_3 · TiO_2 ; 16 - 20 vol % α - Al_2O_3 inclusions)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(50 - 24 vol % Al_2O_3 - TiO_2 ; 16 - 20 vol % α - Al_2O_3 inclusions)

REFERENCE INFORMATION

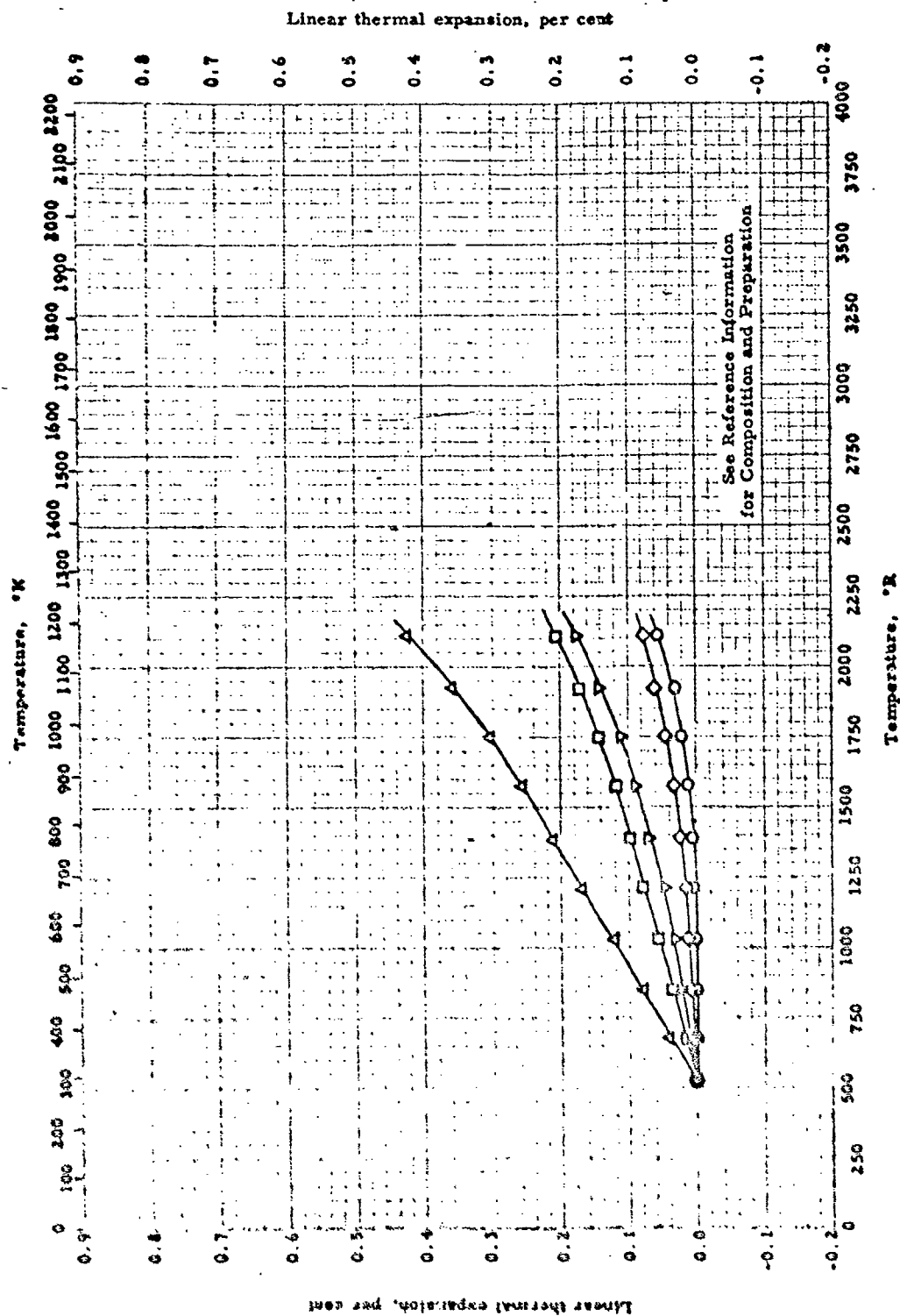
Investigator	Ref.	Specs., #	Material Composition	Test Method	Remarks
O Koch, W. J. and Hoffman, C. C.	50-12	522-1112	22.5 vol % Al_2O_3 + TiO_2 crystals, 16.2 vol % α - Al_2O_3 inclusions; 0.3 vol % mineral im- purities, apparent porosity 23.9%	Not given	Ignited γ - Al_2O_3 (μ) and s.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr to 680°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled Same as above
G Bick	50-13	522-1112	20.2 vol % Al_2O_3 - TiO_2 crystals, 19.8 vol % α - Al_2O_3 inclusions; 0.3 vol % mineral im- purities, apparent porosity 27.0%	Same as above	

59-586

WADC TR 58-476

1135

VII - E



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(91 - 9% vol % Al_2O_3 · TiO_2 ; 5 - 8 vol % α - Al_2O_3 Inclusions)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(91 - 94 vol % Al_2O_3 - TiO_2 ; 5 - 8 vol % α - Al_2O_3 inclusions)

REFERENCE INFORMATION

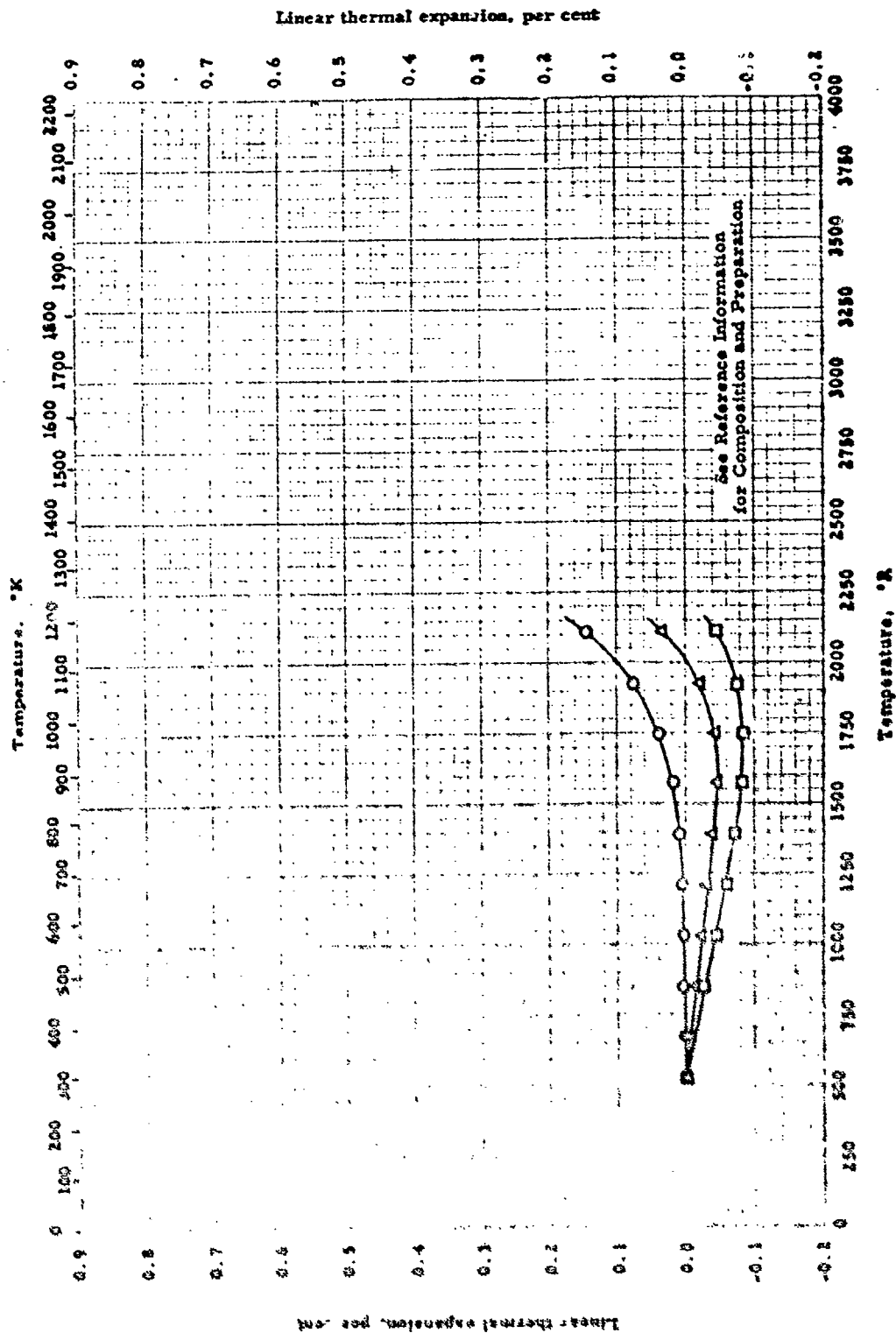
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W. J. and Harman, C. G.	50-12	528-2112	92.8 vol % Al_2O_3 - TiO_2 crystals; 7.2 vol % α - Al_2O_3 inclusions; apparent porosity 30.1%	Not given	Ignited γ Al_2O_3 (1 μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr to 650°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled
□	Idid.	50-12	528-2112	92.0 vol % Al_2O_3 - TiO_2 crystals; 8.0 vol % α - Al_2O_3 inclusions; apparent porosity 27.5%	Same as above	Same as above
△	Idid.	50-12	528-2112	91.7 vol % Al_2O_3 - TiO_2 crystals; 7.3 vol % α - Al_2O_3 inclusions; 1% mineral impurities, apparent porosity 26.8%	Same as above	Fused Al_2O_3 (6 μ) and c.p. TiO_2 treated as above
○	Idid.	50-12	528-2112	93.7 vol % Al_2O_3 - TiO_2 crystals; 5.3 vol % α - Al_2O_3 inclusions; 1% mineral impurities, apparent porosity 22.3%	Same as above	Same as above
▽	Idid.	50-12	528-2112	91.1 vol % Al_2O_3 - TiO_2 crystals; 7.9 vol % α - Al_2O_3 inclusions; 1.0% mineral impurities, apparent porosity 15.8%	Same as above	Same as above

59-587

WAD: TR 58-476

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VI - K

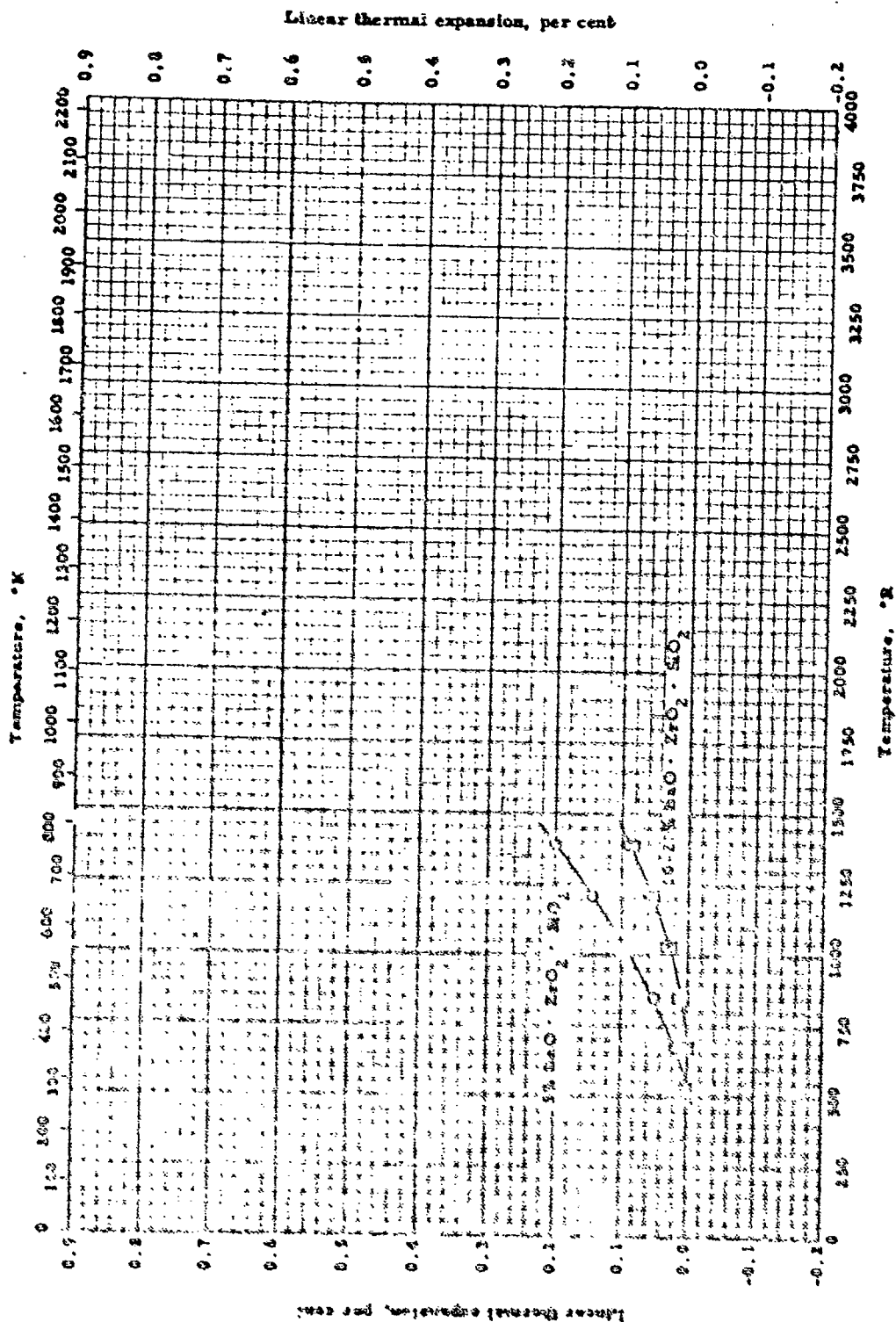


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(51 - 90 vol % Al_2O_3 ; TiO_2 ; 1 - 3 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(81 - 99 vol % Al_2O_3 - TiO_2 ; 1 - 3 vol % Mullite)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Temp., °F	Material Composition	Test Method	Remarks
0	Koch, W. J. and Warman, C. C.	50-12	118-2112	85.3 vol % Al_2O_3 - TiO_2 crystals; 9.7 vol % isotropic glass; 1.0 vol % mullite crystals; apparent porosity 8.4%	Net p/ven	Equimolar mix of ignited $\gamma\text{-Al}_2\text{O}_3$ (14) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in. ²), fired in 8 hr to 650°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled, reground mixed with c.p. TiO_2 , refired to 1650°C
0	Und.	50-12	118-2112	61.3 vol % Al_2O_3 - TiO_2 crystals; 15.7 vol % isotropic glass; 1.0 vol % mullite crystals; apparent porosity 5.76%	Same as above	Same as above
4	Und.	50-12	118-2112	81.3 vol % Al_2O_3 - TiO_2 crystals; 17.7 vol % isotropic glass; 1.0 vol % mullite crystals; apparent porosity 5.13%	Same as above	Same as above



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH BaO-ZrO₂-SiO₂

59-299

WADC TR 58-476

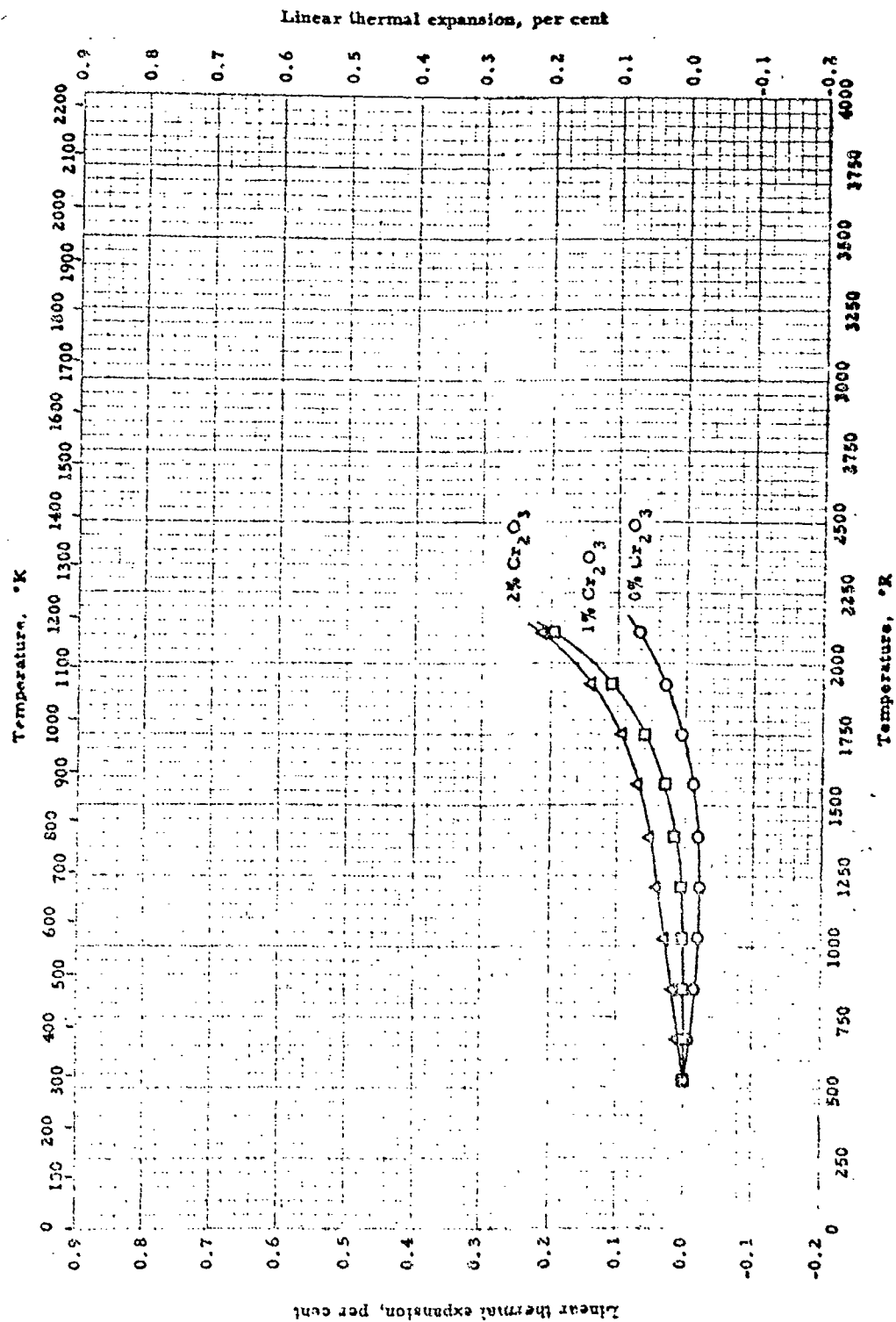
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LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH BaO-ZrO₂-SiO₂

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Zimmerman, W. F. Planckhorn, W. J. and Bennett, D. G.	53-42	528-1392	95% Al ₂ O ₃ · TiO ₂ 5% BaO · ZrO ₂ · SiO ₂	Interferometer	
□	Id.	53-42	528-1392	90% Al ₂ O ₃ · TiO ₂ ; 10% BaO · ZrO ₂ · SiO ₂	Same as above	
Δ	Id.	53-42	528-1392	80% Al ₂ O ₃ · TiO ₂ ; 20% BaO · ZrO ₂ · SiO ₂	Same as above	



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH Cr_2O_3

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH Cr_2O_3

REFERENCE INFORMATION

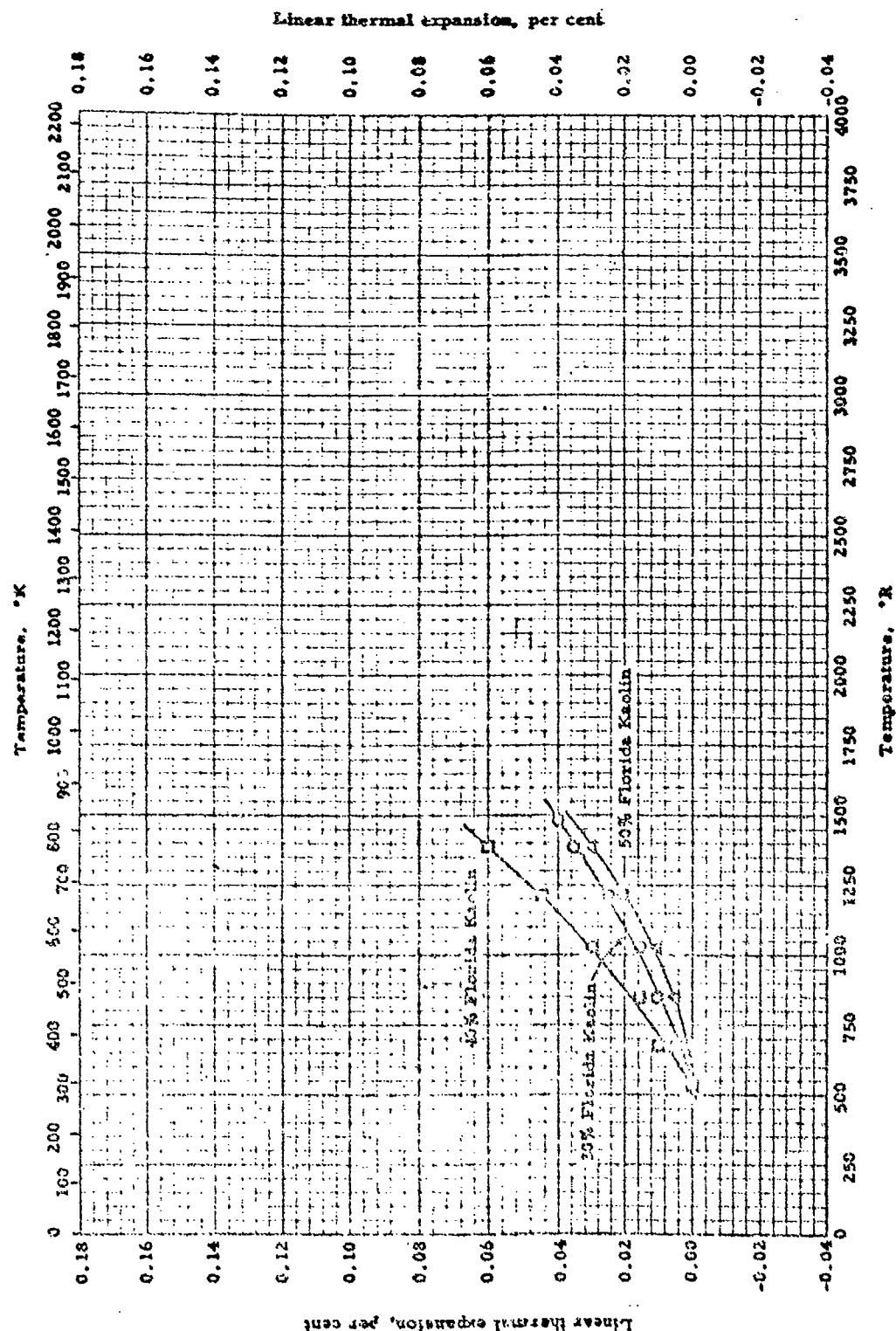
Ref.	Investigator	Ref.	Range, °E	Material Composition	Test Method	Remarks
O	Koch, W. J. and Harman, C. G.	50-12	528-2112	100% $\text{Al}_2\text{O}_3 \cdot \text{TiO}_2$	Not given	Equimolar Al_2O_3 and TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in ²), fired in 8 hr. to 650°C, fired in 26 hr. to 1820°C, held 1 hr., furnace cooled
□	Ibid.	50-12	528-2112	99% $\text{Al}_2\text{O}_3 \cdot \text{TiO}_2$; 1% Cr_2O_3	Same as above	Above material ground, Cr_2O_3 added, refired to 1650°C
△	Ibid.	50-12	528-2112	98% $\text{Al}_2\text{O}_3 \cdot \text{TiO}_2$; 2% Cr_2O_3	Same as above	Same as above

59-300

WADC TR 58-476

1143

VII - E

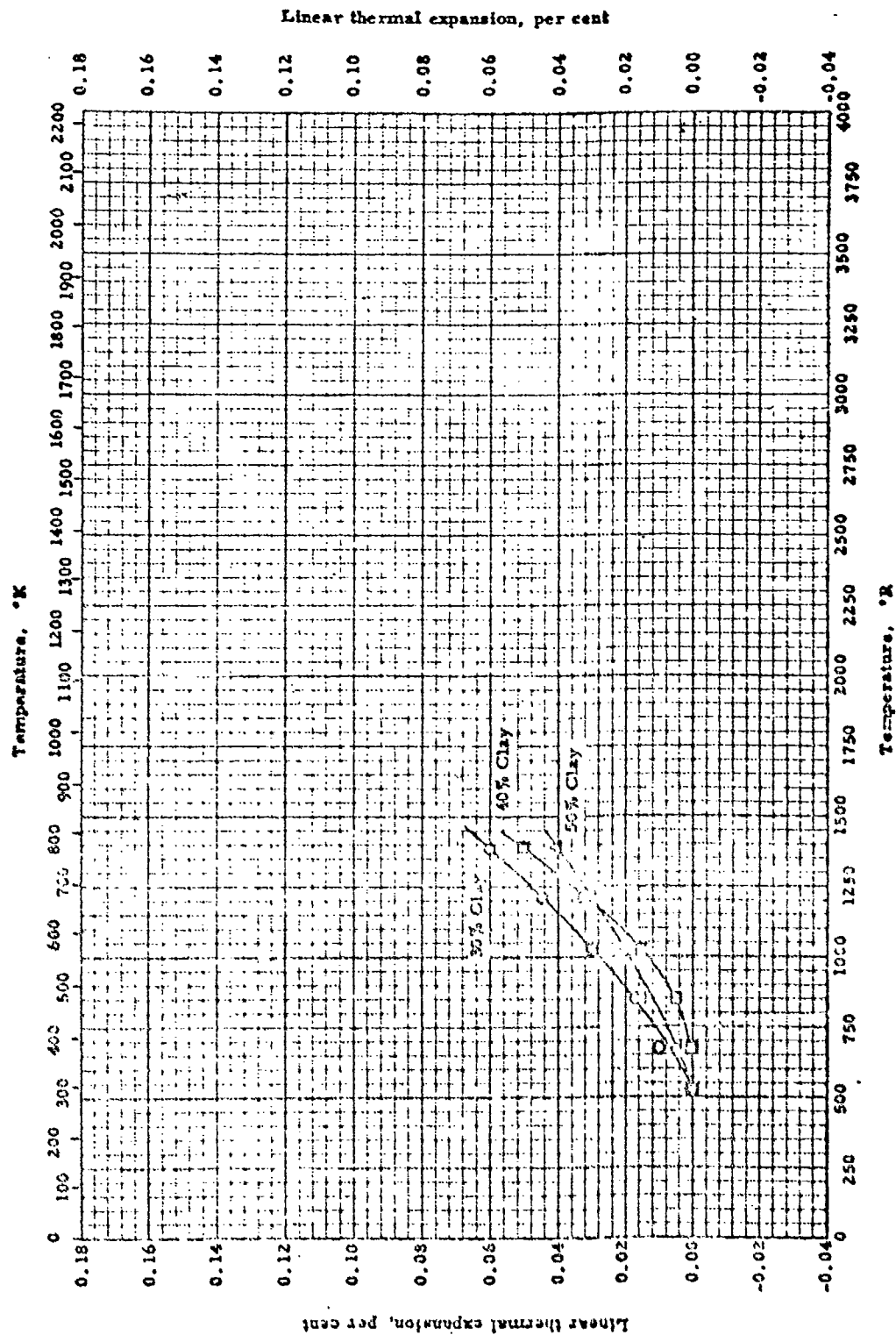


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH FLORIDA KAOLIN

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH FLORIDA KAOLIN

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	Zimmerman, W. F., Flaekenborn, W. J., and Bennett, D. G.	53-42	528-1462	70% $Al_2O_3 \cdot TiO_2$; 30% Florida Kaolin	Interferometer	
C	Ibid.	53-42	528-1392	60% $Al_2O_3 \cdot TiO_2$; 40% Florida Kaolin	Same as above	
Δ	Ibid.	53-42	528-1391	50% $Al_2O_3 \cdot TiO_2$; 50% Florida Kaolin	Same as above	

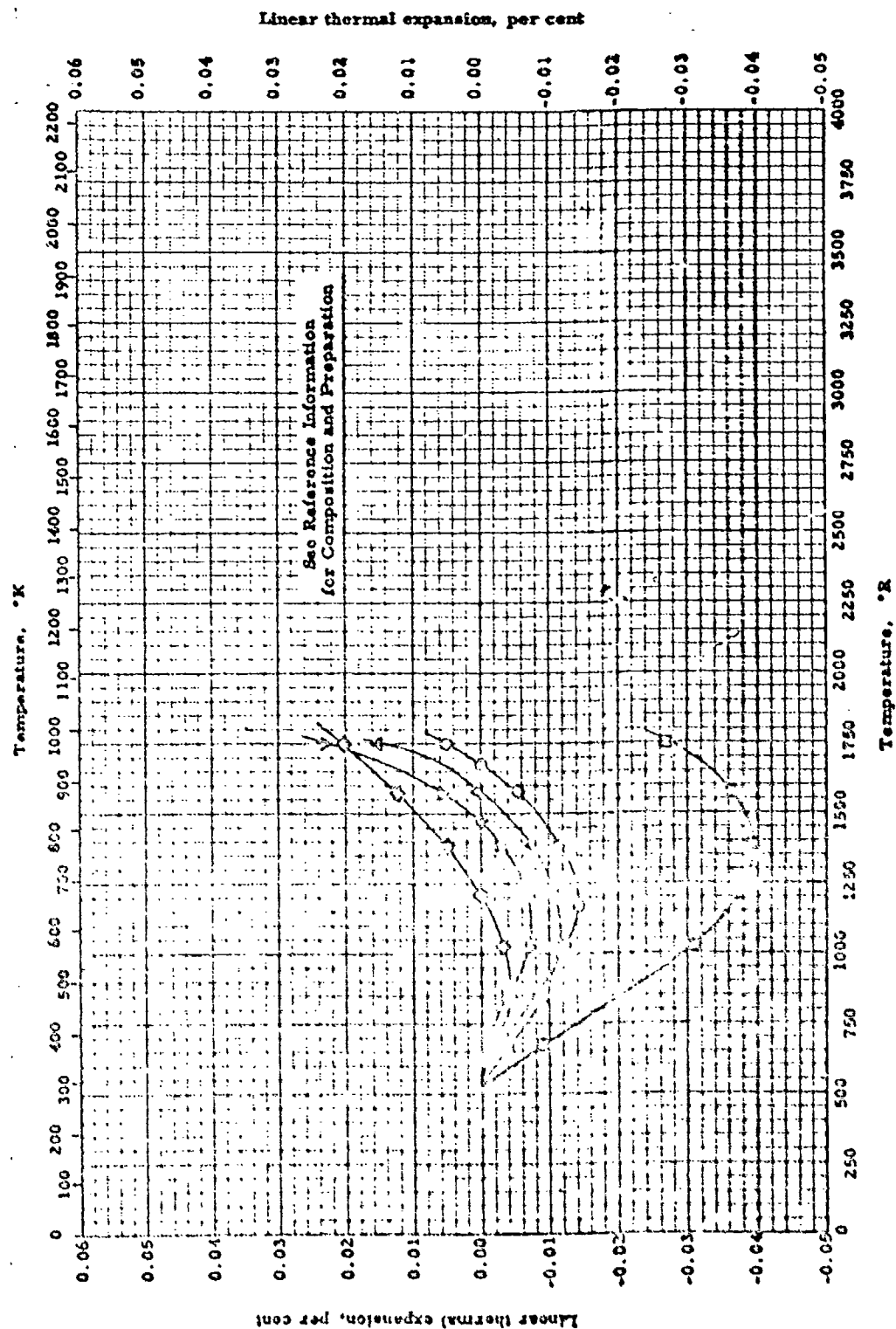


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH FULTON PLASTIC CLAY

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH FULTON PLASTIC CLAY

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
Q	Zimmerman, W. F. Ziabenhorn, W. J. and Bennett, D. G.	53-42	528-1392	75% Al_2O_3 , TiO_2 ; 30% Fulton plastic clay	Interferometer	
□	Ibid.	53-42	528-1392	50% Al_2O_3 , TiO_2 ; 40% Fulton plastic clay	Interferometer	
Δ	Ibid.	53-42	528-1392	50% Al_2O_3 , TiO_2 ; 50% Fulton plastic clay	Interferometer	

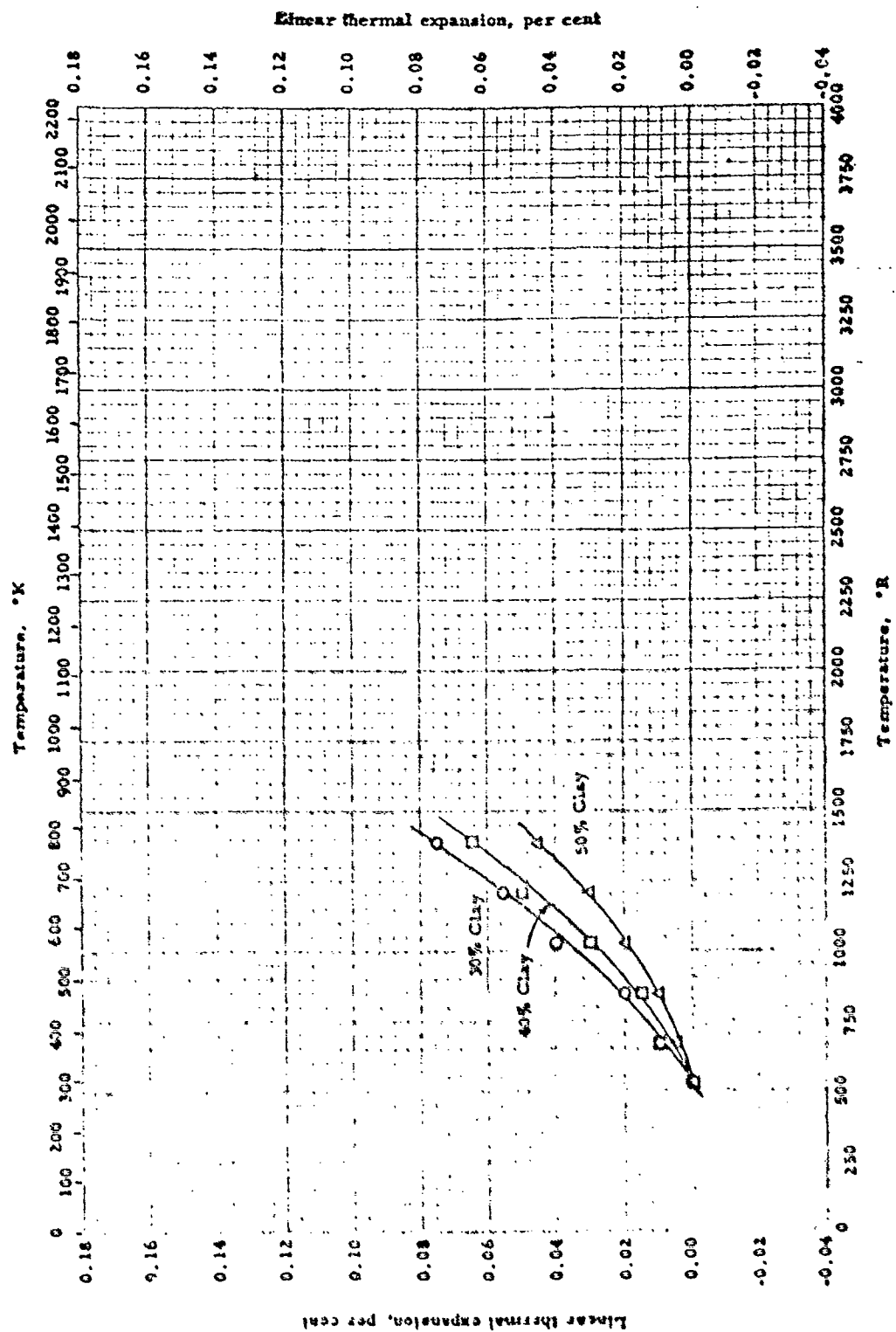


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH PETALITE AND E.P.K. CLAY

**LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH PETALITE AND E. P. K. CLAY**

REFERENCE INFORMATION

Investigator	Ref.	Temp., °R	Material Composition	Test Method	Remarks
○ New Jersey Ceramic Research Station	55-22	672-1752	60% petalite; 40% $Al_2O_3 \cdot TiO_2$; prepared from petalite + $Al_2O_3 + TiO_2$ (equimolar mix)	Fused silica tube dilatometer	Tested at 2-3°C/min. rise
□ Ibid.	55-22	672-1752	Same as above; prepared from petalite + $Al_2O_3 \cdot TiO_2$	Same as above	Tested at 2-3°C/min. rise. $Al_2O_3 \cdot TiO_2$ formed by pressing, firing to 2800°F, crushing, grinding to 200 mesh
△ Ibid.	55-22	672-1752	50% petalite; 40% $Al_2O_3 \cdot TiO_2$; 10% E. P. K. clay	Same as above	Same as above
◇ Ibid.	55-22	672-1752	40% petalite; 40% $Al_2O_3 \cdot TiO_2$; 20% E. P. K. clay	Same as above	Same as above
▽ Ibid.	55-22	672-1752	45% petalite; 30% $Al_2O_3 \cdot TiO_2$; 7.5% E. P. K. clay; 7.5% feldspar (Buckingham)	Same as above	Same as above

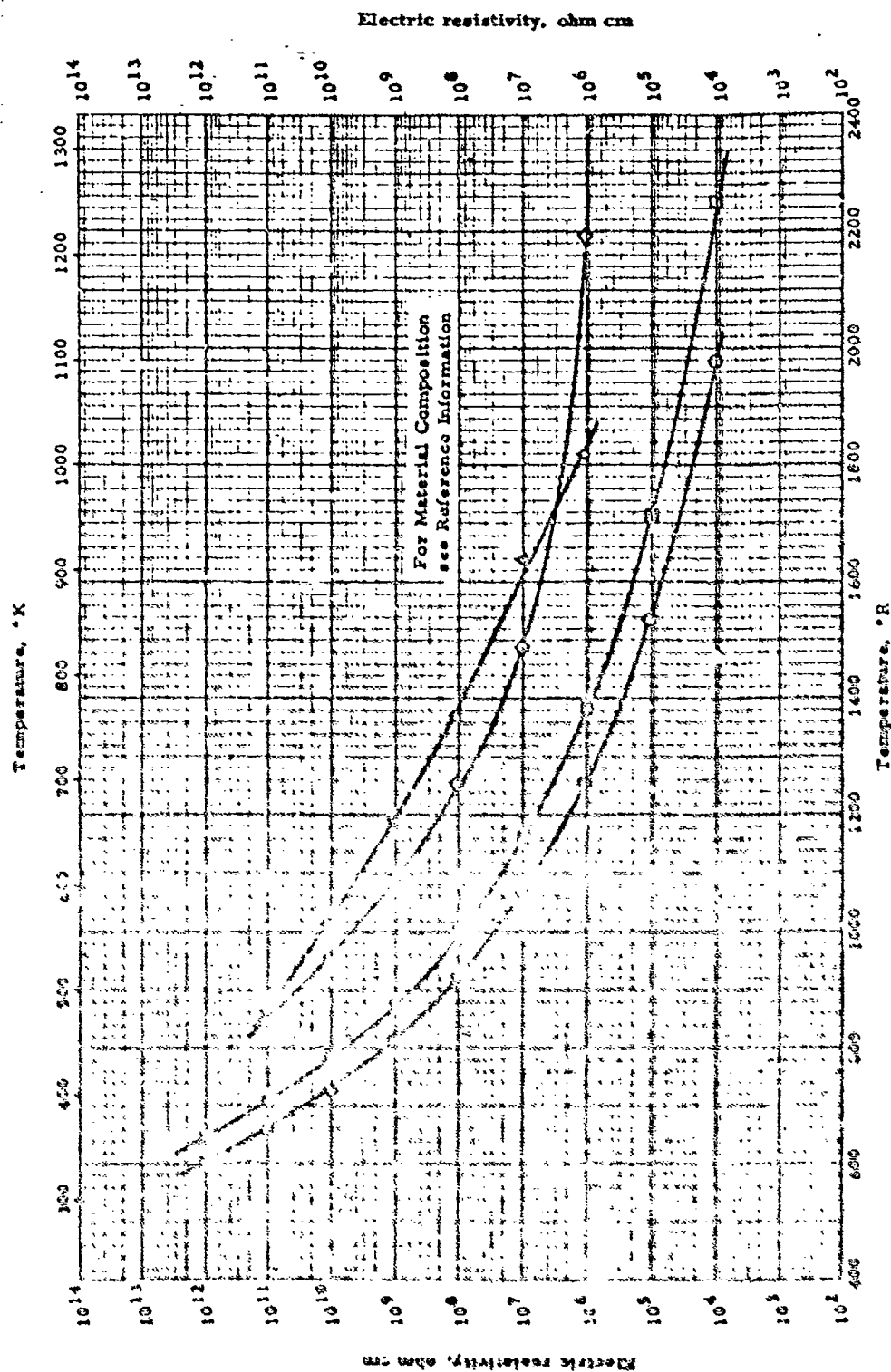


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH TENNESSEE NO. 5 BALL CLAY

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
WITH TENNESSEE NO. 5 BALL CLAY

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
1	Zimmerman, W. F. Pamplin, W. J. and Bennett, D. G.	53-42	528-1392	10% Al_2O_3 , TiO_2 ; 50% Tennessee No. 5 Ball Clay	Interferometer	
2	Ref.	53-42	528-1392	60% Al_2O_3 , TiO_2 ; 40% Tennessee No. 5 Ball Clay	Same as above	
3	Ref.	53-42	528-1392	70% Al_2O_3 , TiO_2 ; 30% Tennessee No. 5 Ball Clay	Same as above	



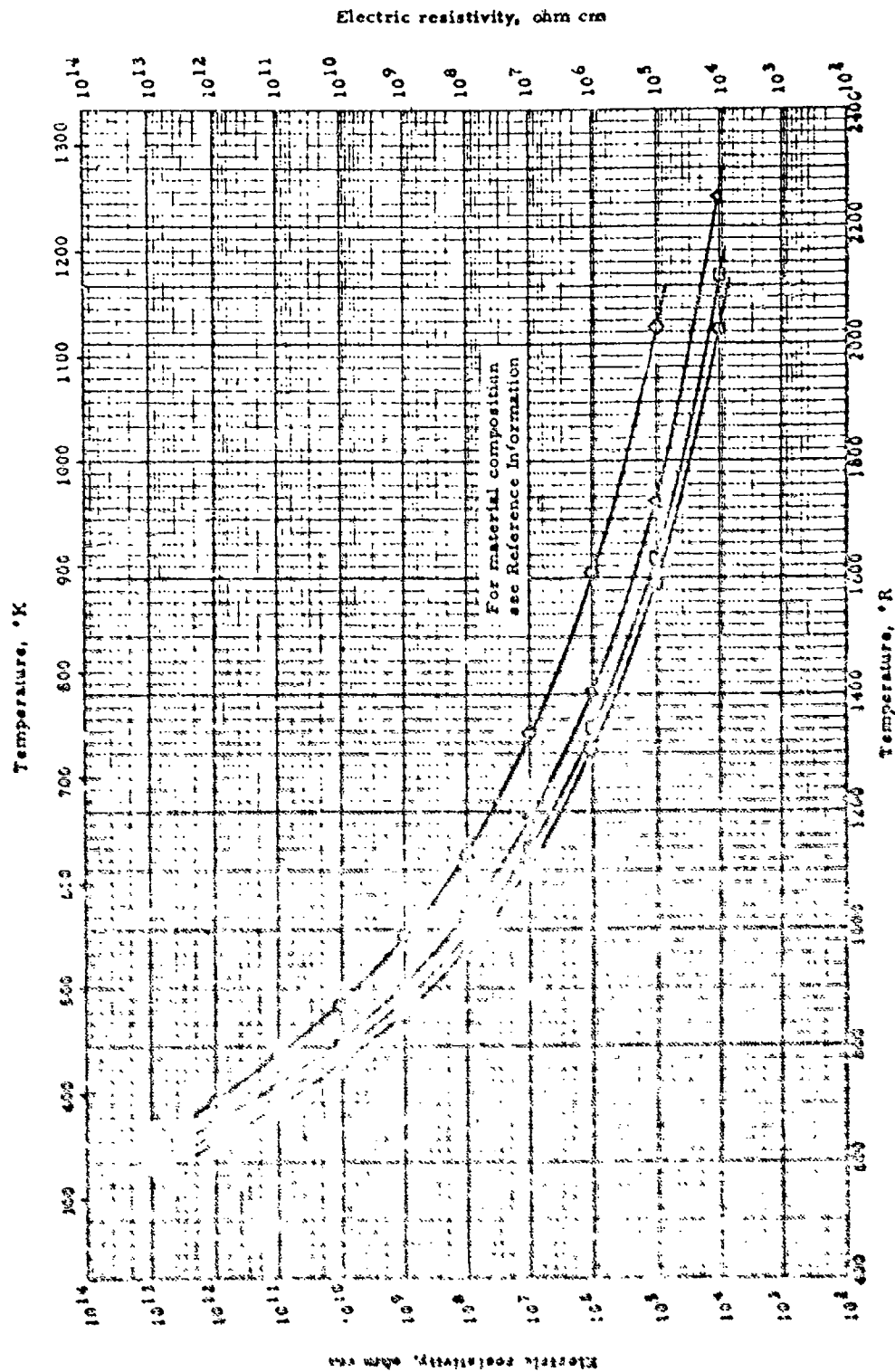
ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(72-74 wt% Al₂O₃ · TiO₂; 12-27 vol% α-Al₂O₃ Inclusions; 0-11 vol% Mullite)

ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(22-72 wt% Al_2O_3 - SiO_2 ; 12-27 wt% $\alpha-Al_2O_3$ inclusions; 0-11 vol% Mullite)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
1	Loeb, W. J. and Hickman, C. G.	50-12	601-1478	77.0 wt% Al_2O_3 - TiO_2 crystals; 15.6 wt% isotropic glass; 2.0% mullite crystals. Apparent porosity = 6.50%. Interstitial material of mullite and glass with average crystal size of 23 μ .	Not given	Equimolar mix of Al_2O_3 and TiO_2 fused, powdered, fired to 1650°C
2	DoId.	50-13	643-1150	74.6 wt% Al_2O_3 - TiO_2 crystals; 19.1 vol% $\alpha-Al_2O_3$ inclusions; 6.4 vol% mullite crystals; 0.9% isotropic glass. Apparent porosity = 5.81%	Same as above	59.9% equimolar mix of ignited $\gamma-Al_2O_3$ and TiO_2 powdered, mixed with 40.1% Al_2O_3 , fired to 1656°C
3	DoId.	50-12	960-1818	75.3 wt% Al_2O_3 - TiO_2 crystals; 23.7 vol% $\alpha-Al_2O_3$ inclusions; 1.3 vol% mineral impurities. Apparent porosity = 16.0%	Same as above	69.6% fused Al_2O_3 and 30.4% c.p. TiO_2 ball-milled, dried at 110°C, 5% wax binder added, pressed at 10,000 lb/in ² , fired to 650°C in 8 hr. to remove binder, heated to 1820°C in 26 hr., held 1 hr., furnace cool 1 to room temp.
4	DoId.	50-12	857-1196	72.1 wt% Al_2O_3 - TiO_2 crystals; 26.9 vol% $\alpha-Al_2O_3$ inclusions; 1.0 vol% mineral impurities. Apparent porosity = 10.5%	Same as above	Same as above, except 71.9% fused Al_2O_3 and 28.1% c.p. TiO_2 were milled.

60-576
WADC TR 53-476

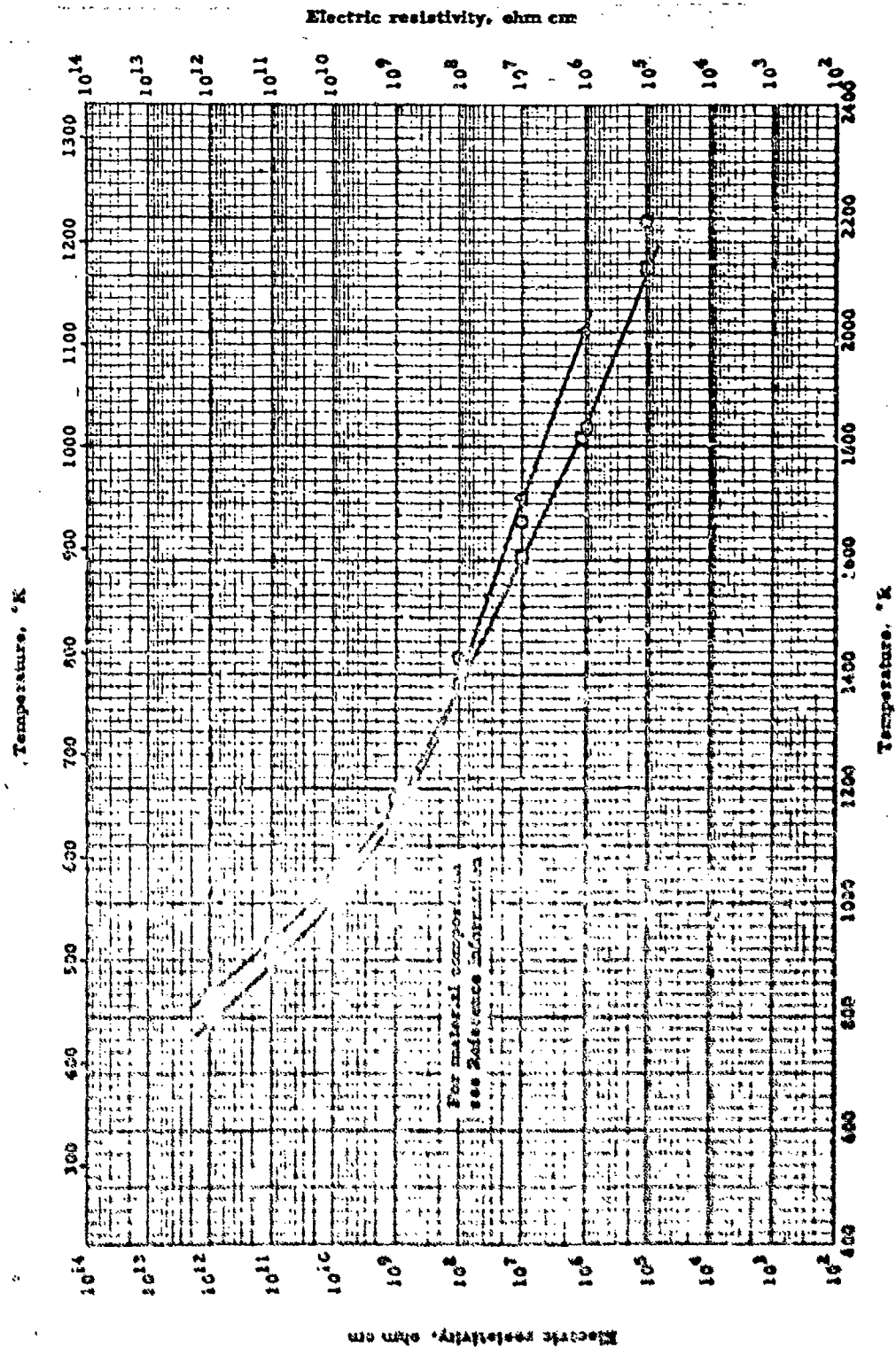


ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(80-90 wt% Al_2O_3 , TiO₂; 0-10 vol% α - Al_2O_3 Inclusions; 1-16 vol% Mullite)

ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(30-40 vol. % Al_2O_3 - TiO_2 ; 0-10 vol. % α - Al_2O_3 inclusions; 1-16 vol. % Mullite)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
C	Koch, W. J. and Harmen, C. G.	30-12	1039-2023	21.2 vol. % Al_2O_3 - TiO_2 crystals; 15.7 vol. % isotropic glass; 2.0 vol. % mullite crystals. Apparent porosity = 5.76%	Not given	Equimolar mix of ignited γ - Al_2O_3 and c.p. TiO_2 prepared, reground, mixed with c.p. TiO_2 as required, refired to 1650°C
Q	D&L	30-12	1048-2117	21.2 vol. % Al_2O_3 - TiO_2 crystals; 17.7 vol. % isotropic glass; 1.0 vol. % mullite crystals. Apparent porosity = 5.35%	Same as above	Same as above
A	D&L	30-12	1046-2233	19.3 vol. % Al_2O_3 - TiO_2 crystals; 9.7 vol. % isotropic glass; 1.0 vol. % mullite crystals. Apparent porosity = 8.40%	Same as above	Same as above
Q	D&L	30-12	1709-2023	21.2 vol. % Al_2O_3 - TiO_2 crystals; 4.2 vol. % mullite crystals; 4.9 vol. % α - Al_2O_3 inclusions; 2.0 vol. % isotropic glass. Apparent porosity = 5.57%	Same as above	59.9% fused Al_2O_3 - TiO_2 powdered, mixed with 40.1% fused Al_2O_3 , fired to 1650°C



60-773

WADC TR 58-476

1156

Electric resistivity, ohm cm

VII - E

ELECTRIC RESISTIVITY - VITREOUS BONDED ALUMINUM TITANATE
(91-94 wt% Al₂O₃ - TiO₂, 5-8 vol% α - Al₂O₃ Inclusions)

ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(91.94 vol% $Al_2O_3 \cdot TiO_2$; 5-8 vol% $\alpha - Al_2O_3$ inclusions)

REFERENCE INFORMATION

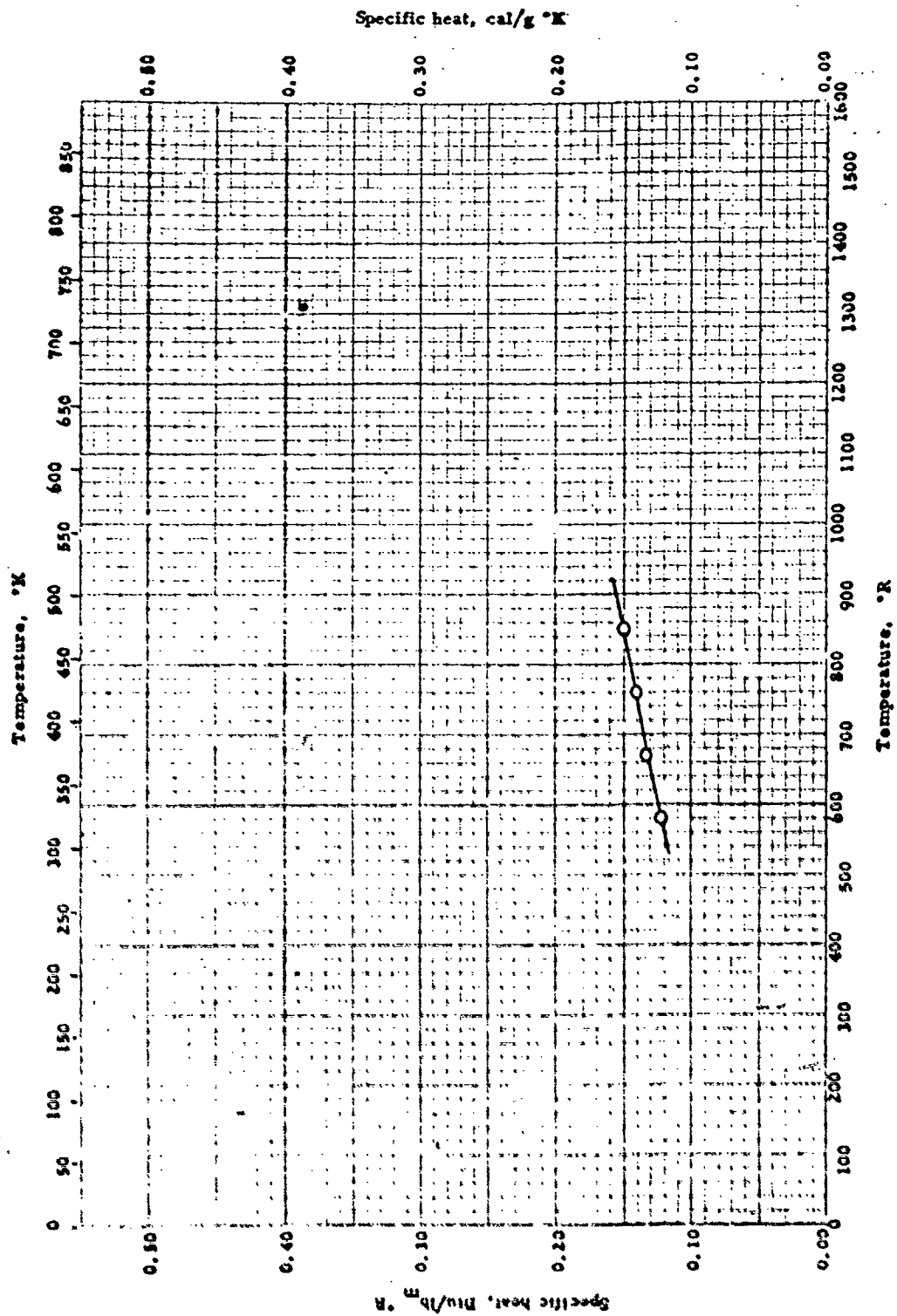
Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Boch, W. J. and Marman, C. G.	50-12	256-2176	91.7 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 5.3 Vol% $\alpha - Al_2O_3$ inclusions; 1.0 Vol% mineral impurities. Porosity = 22.3%	Not given	Ball milled, dried at 110°C, wax added, pressed at 10,000 psi, fired 1 hr. at 650°C, raised to 1820°C in 26 hr., held 1 hr. at 1820°C. Furnace cooled to room temp.
□	D14.	50-12	241-2117	91.7 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 7.3 Vol% $\alpha - Al_2O_3$ inclusions; 1.0 Vol% mineral impurities. Porosity = 26.6%	Same as above	Same as above
△	D14.	50-12	793-2000	91.1 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 7.9 Vol% $\alpha - Al_2O_3$ inclusions; 1.0 Vol% mineral impurities. Porosity = 15.6%	Same as above	Same as above

59-823

WADC TR 58-476

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F - 11A

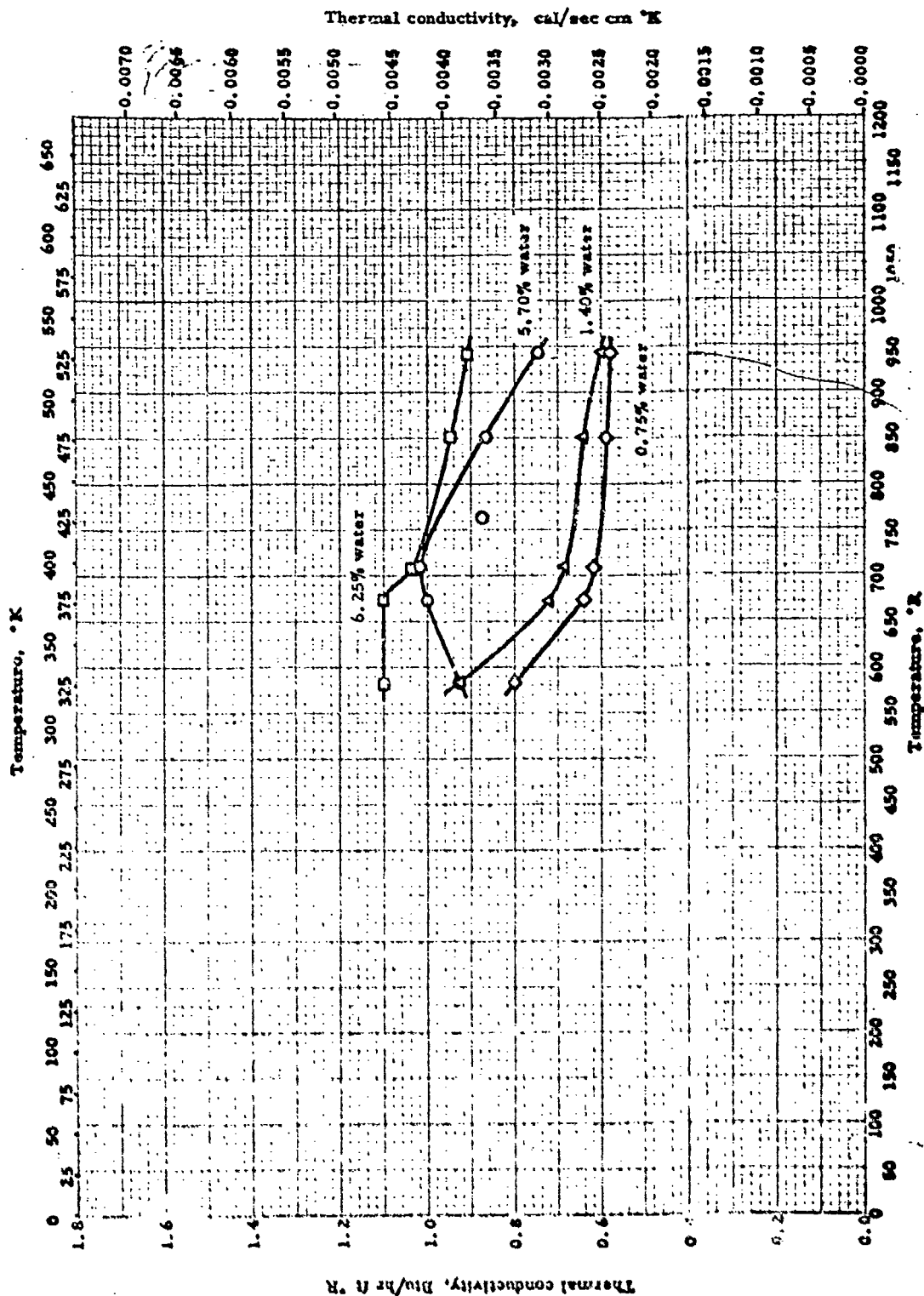


SPECIFIC HEAT -- PORTLAND CEMENT - BARYTES AGGREGATE

SPECIFIC HEAT -- PORTLAND CEMENT - BARYTES AGGREGATE

REFERENCE INFORMATION

Spec No.	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
0	Gallaher, R. B. and Kittes, A. E.	53-63	582-852	48.1% of 1-in. Sweetwater barytes; 41.9% of 3/8-in. Sweetwater barytes; 10% Portland cement. (Sweetwater barytes contain 95.9% BaSO ₄ , 1.3% O ₂ , 1% Fe; 0.5% Ca). $\rho = 218 \text{ lb}_m / \text{ft}^3$	Drop method; water calorimeter	



60-58A
WADC TR 58-476 1159

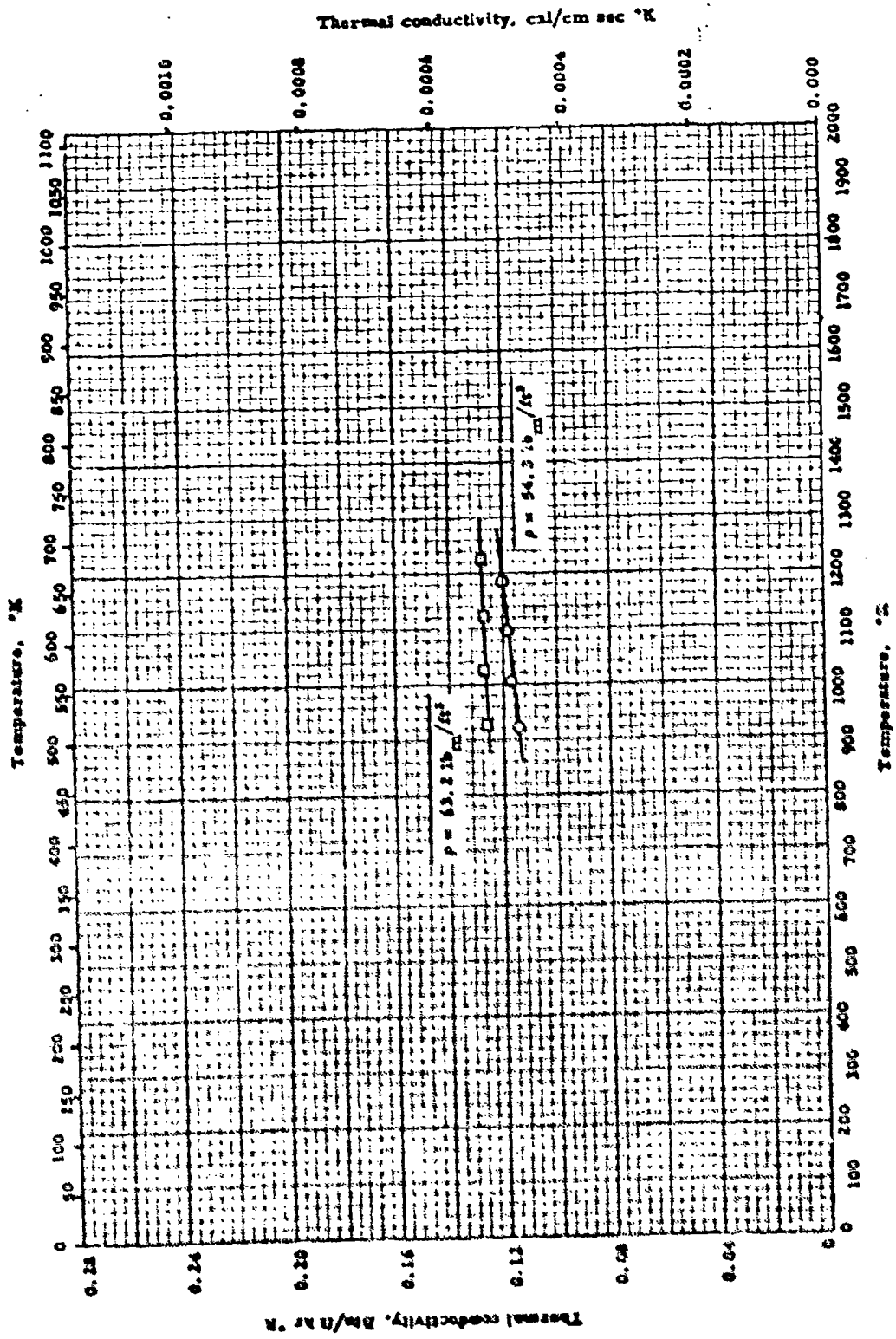
VII - F

Thermal conductivity -- Portland Cement-Barytes Aggregate

THERMAL CONDUCTIVITY -- PORTLAND CEMENT-BARYTES AGGREGATE

REFERENCE INFORMATION

Sym No.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Callahan, R. B. and Matus, A. S.	53-63	582-942	Barytes concrete. Dry ingredients for pouring: 48.1% 1" sweetwater barytes; 41.9% 3/8" sweetwater barytes; 10% Portland cement (type I or II). Dry ingredients for blocks: 91.4% 1 1/2" sweetwater barytes; 8.6% Portland cement (type I or II). p = 220 lb _m /ft ³ 1" barytes contain: 95.9% BaSO ₄ ; 1% Fe; 1.3% O ₂ ; 0.5% Ca. Bulk p = 162 lb _m /ft ³ ; 18% voids. 3/8" barytes contain: 81.6% BaSO ₄ ; 9.8% Fe; 6.2% O ₂ ; 0.9% Ca. Bulk p = 159 lb _m /ft ³ ; 15% voids. Sample with 5.7% water (normal)	Radial heat flow towards center of cylinder, ends guarded. Heat flow meas. by temp. rise of water passing through center	
□	Did.	53-63	582-942	Same as above except 6.25% water	Same as above	
△	Did.	53-63	582-942	Same as above except 1.40% water	Same as above	
◇	Do.	53-63	582-942	Same as above except 0.75% water	Same as above	



Thermal conductivity -- LIGHTWEIGHT CONCRETE

THERMAL CONDUCTIVITY -- LIGHTWEIGHT CONCRETE

REFERENCE INFORMATION

Ref.	Investigator	Range, °R	Material Composition	Test Method	Remarks
97-175	Statul, B. M. and Prasad, J.	923-1185	Lightweight concrete. $p = 54.3 \text{ lb}_m/\text{ft}^3$	Single flat plate; water calorimeter	
97-175	Statul, B. M. and Prasad, J.	923-1185	Same as above. $p = 61.2 \text{ lb}_m/\text{ft}^3$	Same as above	